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# The Profile of the Quality Professionals in the 21st Century

Master's Thesis

Engineering and Quality Management

Work done under the guidance of

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DECLARATION

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## ABSTRACT

This thesis proposes the profile – skills and competences – of the Quality Professional of the 21st Century. In the authors opinion this is an important and needed contribution to the field of Quality due to the fact that it is important to understand whether Quality Professionals are ready or not to face the new challenges of the industry today. We, as Quality Professionals, are still using methodologies and tools that have been proposed in the 20s, 50s or 80s of the last century and they are still very important to improve the processes performance in the companies, but a question should be raised up – Are these methodologies and tools enough and aligned with the current requirements, needs and expectations of the companies? The revision of literature carried out enabled the identification of several research gaps. The main gap concerns with respondents' sample. The worldwide survey carried out enabled the assessment of the perceptions from respondents around the world. The main purpose of this research is to define the profile of the 21st Century Quality Professional, based on the perspectives of worldwide Quality Leaders and Quality Professionals. To accomplish it, an international survey was designed and developed aiming at the collection of the contributions of worldwide Quality Practitioners. The results highlight that "Management Skills" are the most important skills and competences for Quality Professionals of the 21st Century. Leadership Skills are considered by the respondents next most important skills and competence group. Rest of the skill groups were rated by the respondents respectively; Soft Skills, Technical Skills and Analytical Skills. Several statistical tests were carried out namely those to ascertain the internal consistency of the data set (Reliability Analysis) and the statistical significance of the differences between grouping variables (Kruskal-Wallis Test). Results suggest that the assessment of some variables differ according to some grouping variables. From a practical point of view, this research will contribute to support companies in the definition of the Quality Professional profile needed to face Quality and the Innovation of the 21st century. The assessment of the main cause of those differences can be shown as further research example.

## KEYWORDS

Quality Professionals, Skills and Competences, Quality of 21st Century, Quality 4.0, Worldwide Survey.

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## List Of Abbreviations And Acronyms

APQC – American Productivity & Quality Center
ASQ – American Society for Quality
CBM – Cloud Based Manufacturing
CEO – Chief Executive Officer
CPS – Cyber Physical Systems
CRM – Customer Relationship Management
ERP – Enterprise Resource Planning
IAQ – International Academy for Quality
IIoT – Industrial Internet of Things
IMS – Information Management System
IoT – Internet of Things
KMO – Kaiser – Meyer – Olkin
PLC – Programmable Logic Controller
RFID – Radio Frequency Identification
SMEs – Small and Medium Enterprises
SPSS – Statistical Package for the Social Science
SR – Social Responsibility
VP – Vice President

# 1. INTRODUCTION

## 1.1 Framework and Scope of the Project

In a globalized and innovation-based world, skill and competence terms are the key words to survive. By the new world necessities, customers' awareness has increased and they have transformed more demanding, competition has become severe and technological innovations are turned into astonishing status (Oakland, 2005). Besides, there are huge changes across industry. For example, 'Smart Factories' is one of the new changes and also a new concept which emerges from Industry 4.0 (I4.0), Cyber-Physical Systems (CPS), Internet of Things (IoT) and Cloud Based Manufacturing (CBM) (Yildiz, 2018). In such a case, the quality field and Quality Professionals must adapt to this changing world by adopting right skills and competences to deal with these challenges.

This thesis presents the profile – skills and competences – of the Quality Professional of the 21st Century. In the authors' opinion this is an important and needed contribution to the field of Quality due to it is important to understand whether Quality Professionals are ready or not to the new challenges of the industry today. It is important to point out that, in general, we, as Quality Professionals, are still using methodologies and tools that have been proposed in the 20s, 50s or 80s of the last century. These methodologies and tools are still very important to improve the processes performance in the companies, but world is changing at a fast pace and Quality Professionals must make themselves indispensable in this new world (Larson, 1998). According to Larson (Larson, 1998) teamwork, adaptability and people skills are very important for quality. Quality professionals should be strategic thinkers and need to be wise aiming at solving fundamental problems that society is facing (Spichiger, 2002). In addition, they should have more skills and new competencies and must be prepared for the future challenges.

According to Peter Merrill, innovation is going to be the subsequent universe where Quality Professionals can leave their own trace. Quality Professionals are going to focus customer needs more than common requirements. Also, thanks to the use of innovation they are going to point out needs that even customers did not demand due to the current market's limitations (Merrill, 2012). Innovation is abundantly relevant to the quality; therefore, it needs to be precondition for companies for the growth. Along with extensive connections between innovation and quality, we can have a lot benefit from how quality can drive innovation and how innovation can drive quality. While quality's baseline remains unchanged, on the other hand organizational culture, tools and concepts are changed day by day. Therefore, in the daily life people need to deal with these new concepts such as Industry 4.0 (I4.0), Quality 4.0, Internet of Things (IoT), Big Data, among others (Gutner & Adams, 2009). The Quality 4.0 is a quite interesting concept,

because it does not substitute traditional quality methods, but, even better builds and develops them, combining traditional quality methods with new modern technologies to reach out the best performance. In this specific case, the concept of Quality 4.0 embodies Industry 4.0, Big Data and Artificial Intelligence concepts. Quality 4.0 is related to the digitalization of quality management and it links quality management with Industry 4.0 to assist business ability, innovation and business models and performance (Jacob, 2017) .

## 1.2 Objective and Motivation

The main purpose of this research is to define the profile of the Quality Professional of the 21st Century, based on the new challenges that the organizations are currently dealing with from the perspectives of worldwide Quality Leaders and Quality Professionals. To accomplish that, an international survey was carried out to collect the contributions of the worldwide Quality Practitioners. In order to achieve the desired objectives, survey encompassed structured (5 Points Likert Scale) and Open-Ended questions was designed, developed and held online aiming at clarifying the following questions:

- Which are the crucial skills and competencies for the Quality Professionals of the 21st Century?
- Which are the missing skills of Quality Professionals?
- Are current quality tools sufficient to deal with the new industry challenges?
- What are the general expectations from Quality Professionals of the 21st Century?

Additionally, this research will have a very important contribution for the education and training dimensions, namely in terms of providing insights to the Universities and Training Academies aiming at updating and adapting the curricula of Quality Management/Quality Engineering courses, among others, to the needs, requirements and expectations of the modern and future organizations. In the practical perspective, the research will contribute to support companies in the definition of the Quality Professional profile needed to catch the Quality and the Innovation of the 21st Century. The motivation for this work emerges from the need to understand whether current Quality Professionals are ready or not for the requirements of the 21st Century in terms of skills and competences and to ascertain if the current quality tools and techniques should be updated in order to face the new challenges. Furthermore, the conclusions from this thesis will contribute to update the curricula of Quality Management and Engineering courses.

## 1.3 Dissertation Structure

The thesis encompasses 5 chapters.

The first chapter includes introduction of the thesis. General framework and scope of the thesis were explained in detail, then objective of the thesis was determined by asking related questions and also output of the thesis was mentioned. Next, the motivation of work was presented to explain which reason gave inspiration to the authors to work on this study.

Second chapter encompasses related literature review. Reviewing of existing literature was written in this chapter. Related issues such as; Quality, Quality Tools and Techniques, 21st Century Challenges and New Concepts (Smart Factories & Industry 4.0, Quality 4.0, Social Responsibility), Quality Professionals, Skill and Competence were mentioned. Also, research gap that specified according to the current literature was defined in this chapter.

Third chapter includes research methodology, the adopted strategy throughout the research process was exposed. All steps were explained in this chapter in detail and supported by figures.

Fourth chapter encompasses result of applied analysis and discussion of the obtained results. Nearly all analysis was illustrated by figures and tables which obtained from SPSS statistics program.

Fifth chapter, conclusions and further researches, includes a retrospective of the work carried out, the main conclusions and perspectives of future work. In addition to this, some suggestions for further researches are talked in this chapter.

The bibliographical references are also displayed in the bibliography section where placed at last part, to scientifically support the whole study and for the reader to delve into a particular topic that he/she considers relevant. Dissertation structure illustrated in Figure 1.

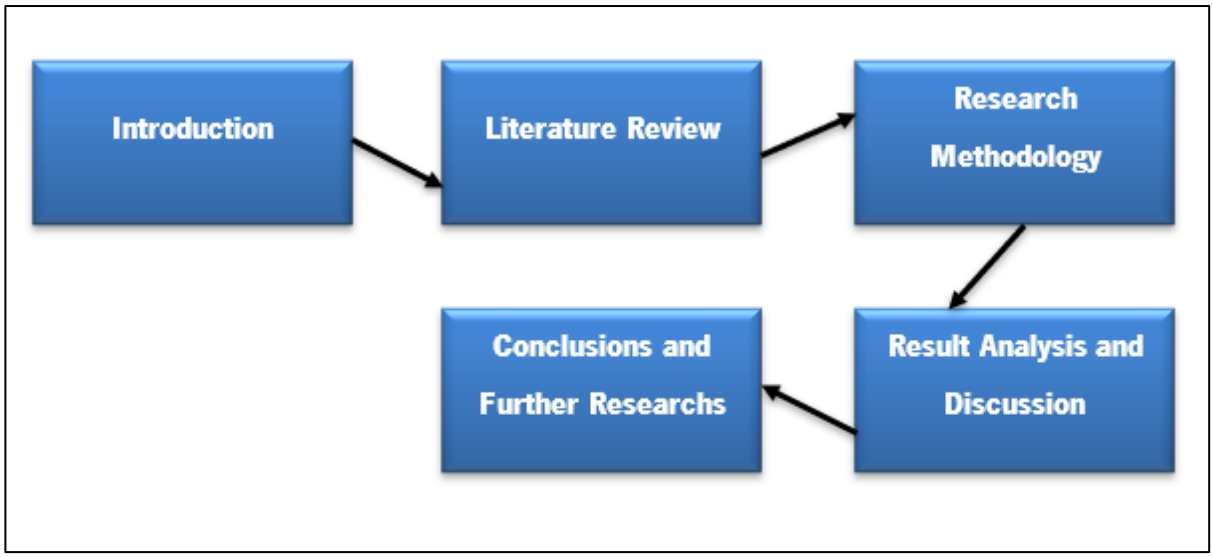



Figure 1 – Dissertation Structure

# 2. LITERATURE REVIEW

## 2.1 Quality: From Past to Future

Contrary to what is believed, quality was not originated in academia but arisen from the real-world practices (Sampaio et al., 2016). The current concept of quality is based on quality management approaches developed by important quality gurus such as Edwards Deming, Joseph M. Juran, Philip Crosby and Kaoru Ishikawa and first implementations of those approaches on the production sector occurred throughout World War II and thereafter. Japanese manufacturers and engineers, who have suffered a major defeat after the war and whose factories were destroyed, invited Deming and Juran to their country on the purpose of compete with United States of America (leader position on the USA and European market) and for changing "low quality" conception of their products. Therefore, companies in Japan started to structure their production process by implementing approaches of Deming and Juran. In the end, Japan overcame USA and, this success, draw the attention from other countries (Cabuk, 2013). So, the abovementioned supports the statement that quality arisen from the "real-world" practices. Quality is what consumer says, wants, needs and expects and also it is generally accepted that consumer satisfaction is related to product/service quality (Shewfelt, 1999). Quality is a concept that cannot be clearly defined. Several gurus and professionals within the organizational and management science identified quality concept differently. It is hard to say that there is a consensus between management science professionals on identifying quality concept. Some of them embraces quality as "absence of errors in the product and service", some of them embraces as "perfection level in the good or service". According to Juran's Quality Handbook (Juran, 1998), there are two critical important meanings of quality:

1) "Quality" means features of products that fulfil needs of customer and enables customer satisfaction. Within this context, quality is income-focused. Improved customer satisfaction and increasing income are the main objectives. However, an investment is needed to increase income. Thus, the increment in costs occurs. In this context, high quality means "costs more".
2) Second important meaning of quality is freedom from deficiencies. Cleaning up the quality from everything that cause to re-work. Such as customer dissatisfaction, customer claims, failures etc. Within this context, quality is cost-focused. Generally, higher quality "costs less" (Juran, 1998). A more detailed presentation on the meanings of quality is available in Table 1.

Table 1 - The meanings of quality [Planning for Quality, 2d ed. (1990). Juran Institute, Inc., Wilton, CT, pp. 1–10.]

| **Product features that meet customer needs** | **Freedom from deficiencies** |
|---|---|
| Higher quality enables companies to:<br>• Increase customer satisfaction,<br>• Make products salable,<br>• Meet competition,<br>• Increase market share,<br>• Provide sales income,<br>• Secure premium prices.<br>The major effect is on sales.<br>Usually, higher quality costs more. | Higher quality enables companies to:<br>• Reduce error rates,<br>• Reduce rework, waste,<br>• Reduce field failures, warranty charges,<br>• Reduce customer dissatisfaction,<br>• Reduce inspection, test,<br>• Shorten time to put new products on the market,<br>• Increase yields, capacity,<br>• Improve delivery performance.<br>Major effect is on cost.<br>Usually, higher quality costs less. |

Quality is widespread concept and several "Quality" definitions are emerged (Table 2).

Table 2 - Definitions for quality from different gurus

| **Quality Gurus** | **Definition** |
|---|---|
| **Masaaki Imai** | When you speak of quality, always product quality comes to mind first, but it is not true. There are three building stones: Hardware, software and human ware. Quality starts with human and then we can talk about hardware and software (Dale & Bunney, 1999) |
| **Kaoru Ishikawa** | In the strict sense, quality means product quality. In a broad sense, it means that work quality, service quality, communication quality, process quality, human quality that includes worker, engineers and managers, system quality, firm quality and targets' quality (Ishikawa, 1995). |

Table 2 – (Continuation) Definitions for quality from different quality gurus

| | |
|---|---|
| **Joseph M. Juran** | Quality means "fitness of use" (Juran, 1998)**.** |
| **Philip B. Crosby** | Quality means "conformance the requirements" (Suarez, 1992). |
| **W. Edwards Deming** | " Quality can be defined only in terms of the agent. Who is the judge of quality? Quality is defined by the satisfaction of the customers, but quality is not static, and customers' needs and expectations are always changing, so definition of quality also changes" (W. Edwards Deming, 1986). |
| **Armand V. Feigenbaum** | According to Feigenbaum quality is a way of the management. To achieve a notable quality every person in the organization must participate into quality activities (Dale & Bunney, 1999). |
| **Genichi Taguchi** | "The quality of a product is the loss imparted to society from the time the product is shipped." (Dale & Bunney, 1999). |

Quality is extremely important to make difference in the progressing and ever changing world. In the past, current and in the future, companies there will be always struggle for superiority. When they are in a competition like this, they have adopted quality for essential competitive advantage (Gherman, Pampa, ILIEŞ, & SĂLĂGEAN, 2013). Kanthassamy Senthilmaran states that (Sampaio et al., 2016), quality is empowering people to make their job well and without limiting the system with non-value procedures and tools. Quality is what customer says and it is not solely about zero-defect product/service. "Quality turned from defect-free to customer focus " stressed Borawski from ASQ (Gutner & Adams, 2009). Quality should be built into all kinds of firm and into each process from the state of raw material to the state of ready to deliver (Sampaio et al., 2016). Concerning the future of quality, the guru 'Dr. Joseph Juran stated that "The 21st Century will be the century of quality". Starting from this point of view, one can ask 'why is quality so important today and even will be more important in the 21st century?' According to Saraiva (2010) (via Sampaio et al., 2016), quality concept is becoming increasingly globalized and due to this reason much more complicated challenges will be faced by organizations. Quality should not be focused solely on organizations and should also be addressed at societal levels (Sampaio et al., 2016). Paulo Sampaio and Pedro Saraiva designated that, there are some issues that are quite relevant in the future:

- Customers are becoming more demanding and better informed than ever before.
- Our life increasingly depends on the proper functioning of quality products and services.

- The world is global and will remain this way (Sampaio et al., 2016).

There is one feature that quality enables sustainable competitive advantage in everywhere it is implemented. Also, it is known that modern quality practices are less common than one might hope. Beside there is a chance for quality to be a force of change in the 21st Century and in every situation quality is going to improve and shape the future (ASQ, 2011).

## 2.2 Quality Tools and Techniques

Several quality tools and techniques were introduced throughout by various experts, but they have remained unchanged until today. Their concepts are still almost the same. Dale and McQuater (1998)(via Tarí & Sabater, 2004) have identified the tools and techniques mostly used by companies, as shown in Table 3.

Table 3 - Mostly used tools and techniques

| **The seven basic quality control tools** | **The seven management tools** | **Other tools** | **Techniques** |
|---|---|---|---|
| Cause and effect diagram<br>Check sheet<br>Control charts<br>Graphs<br>Histogram<br>Pareto diagram<br>Scatter diagram | Affinity diagram<br>Arrow diagram<br>Matrix diagram<br>Matrix data analysis method<br>Process decision program chart<br>Relations diagram<br>Systematic diagram | Brainstorming<br>Control plan<br>Flow chart<br>Force field analysis<br>Questionnaire<br>Sampling | Benchmarking<br>Departmental purpose analysis<br>Design of experiments<br>Failure mode and effect analysis<br>Fault tree analysis<br>Poka yoke<br>Quality costing<br>Quality function deployment<br>Quality improvement teams<br>Statistical process control |

Ishikawa pointed out that the adoption of these tools solve approximately 95% of the quality problems in any type of organization (Fernandes, Sousa, & Lopes, 2013). All tools work well, if people know how to

use them and it is important to know how to select and pick the right tools for the company. Different organizations use different tools and techniques to improve their companies by creating different combinations from different tools and techniques (Sokovic, Pavletic, & Pipan, 2010). Process improvement tools/techniques are shown in Figure 2.


Figure 2 – Process improvement tools/techniques (Quality Support Group, n.d.)

In the (Sampaio et al., 2016), Barbara J. Santiano explains how to use proper tools in the organizations according to her experiences and educational background. As a brief summary, every company can develop its own quality system by obtaining quality concepts and principles that may be implemented in different quality systems. While selecting the tools, one should think about if that tool is important and easy to manage. In a small company, tools must be easy to manage and not all the tools should mandatorily be adopted. The most important part is choosing suitable tools and techniques by the appropriate team and applying the tools into appropriate processes. Success depends on the quality professionals' understanding, knowledge and experiences (Sokovic et al., 2010). A good quality system really can help the organization. It can save time and money, can reduce waiting time, wastes and reworks and finally can make happy their customers.

## 2.3 21st Century Challenges and New Concepts: Smart Factories & Industry 4.0, Quality 4.0, Social Responsibility

In the 21st Century's competitive environment, organizations need some hot concepts to be able to protect and sustain their existences and to compete with their competitors. To accomplish that, they need to understand properly these concepts and try to take advantage of them (Yildiz, 2018). Smart factories & Industry 4.0, Quality 4.0 and Social Responsibility concepts were explained in detailed in the following subsections.

### 2.3.1 Smart Factories and Industry 4.0

Industry, technology and applications are changing at a fast pace and there are many new concepts emerging in the industrial environment. In such a complex environment clear-sighted term Industry 4.0 brought out to shed light on a new industrial revolution (Qin, Liu, & Grosvenor, 2016).

Up to the present, three crucial industrial revolutions have been emerged. Mid of the 18th Century the first industrial revolution has begun. This first industrial revolution (Industry 1.0) was based on the mechanical power generated from steam and water. Followed by second industrial revolution (Industry 2.0) in 1880 that introduced mass production in the assembly lines by means of electrical energy. This period is also known by the adoption of the conveyor to transfer products between machines automatically. After that, third industrial revolution (Industry 3.0) emerged due to the need of integrating the programmable logic controllers (PLC). These programmable logic controllers were invented in 1970s and they made easier the automation of industrial production. In this revolution, unmanned factory is intended, thus started with use of electronics and computers. However, those targets could not fulfill, hence this approach has been denounced as failed.

In this way, first three industrial revolution brought mechanization, electrical and information technology into production made by humans. In 2000's production processes of companies increased in complexity due to changing expectations and requirements. Thus, companies needed interdisciplinary studies and fourth industrial revolution (Industry 4.0) emerged (Can & Kiymaz, 2016; Lo & Chai, 2012; Sayer & Ülker, 2014; Schönreiter, 2017; Yildiz, 2018). Figure 3 summarizes the industrial revolutions so far.

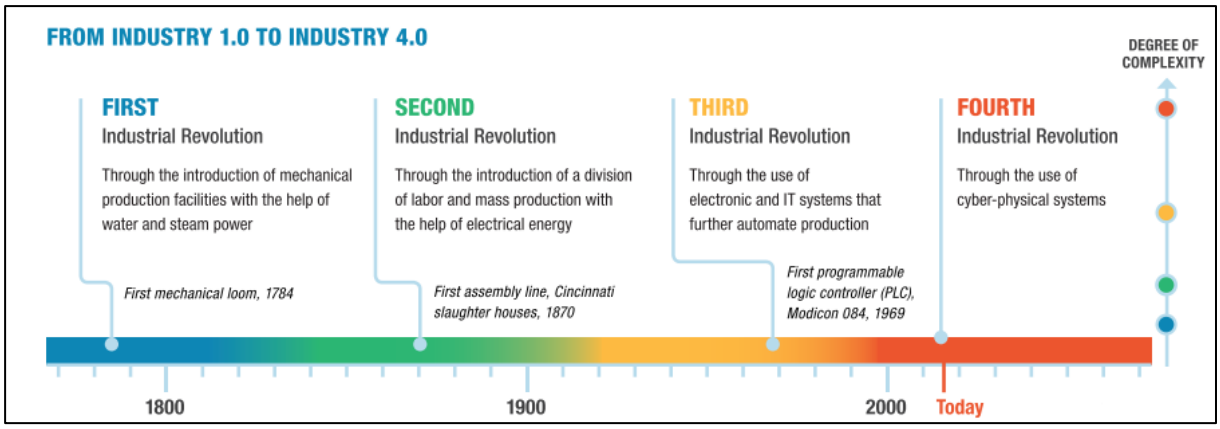



Figure 3 – Industrial Revolutions from Industry 1.0 to Industry 4.0 (Jacob, 2017)

Industry 4.0 was firstly adopted by the German Government in High-Tech Strategy 2020 and introduced in 2011 during the Hannover fair event (Qin et al., 2016). It aims at improving the "Smart Factory" by using technological developments for example, Internet of Things (IoT), Cyber Physical Systems (CPS), Cloud Computing and Big Data to reform the industry to a smart manufacturing systems (Trappey, Trappey, Hareesh Govindarajan, Chuang, & Sun, 2017). It enables companies to conceive "smarter" products and when doing this it reduces cost and increases efficiency (Vuksanović, Ugarak, & Korčok, 2016).

Researchers and practitioners have deep attention for Industry 4.0 due to it can provide productivity increment and wisely using of scarce resources (Samaranayake, Ramanathan, & Laosirihongthong, 2017). Industry 4.0 revolution converted the production from a centralized to a noncentral process and it enabled product to be interactive with machine. This product-machine relationship is complicated, on the other hand it is beneficial for the production process. At the same time this revolution opened a door to enable the ability of self-planning and self-adapting for factories (Witkowski, 2017). Can & Kiymaz (2016) stated that Industry 4.0 predicts that all units, connected to production directly or indirectly, plan the cooperation with each other and digital data, software and information technology works together as integrated. Qin et al., (2016) assumes that Industry 4.0 means that emerged massive communication web between factories, organizations, suppliers, logistic sources and customers. Each section is optimizing their configurations real-timely. Industry 4.0 encompasses numerous technology and related paradigms. Such as; Radio Frequency Identification (RFID), Enterprise Resource Planning (ERP), Internet of Things (IoT), Industrial Internet of Things (IIoT), Cyber-Physical Systems (CPS), Cloud Based Manufacturing (CBM), Smart Factory, Smart Product etc. These features show that, Industry 4.0 is a value-added process. Fundamental concept of Industry 4.0 is shown in Table 4.

Table 4 – Fundamental Concepts of Industry 4.0

| Fundamental Concept | Explanation |
|---|---|
| **Cyber-Physical Systems (CPS)** | Cyber-Physical Systems (CPS) encompasses communication and coordination between physical world and cyber world. The primary target of CPS is to increase productivity of industry (Lu, 2017). |
| **Big Data** | Big Data consist of many sources and can be quantitative or textual. Big Data are caught by using sensors such as industrial sensors or supermarket scanners (Evans, 2015). To use big data properly, having knowledge about new tools of data analysis and deduction is really important, because big data sets are unstructured and all mixed up (Evans, 2015; Waddell & Stewart, 2013). |
| **Internet of Things (IoT)** | Internet of Things (IoT) was generated by Kevin Ashton in 1999 to describe the system that physical world communicates with computers and with sensors (Witkowski, 2017). In the first 10 years of 21st Century, concept of Internet of Things became very popular and is made believe as a technology that helps to industries passing to Industry 4.0 from Industry 3.0 by adding information into products and processes in the supply chain (Trappey et al., 2017). |
| **Customers** | Industry 4.0 provides advantages for customers as well. Customer can order whatever function of product with any number what they want and also, they can change their orders during the production time freely. In addition to this, industry 4.0 provides the utilization advice of product according to customers' own attitudes (Schlechtendahl, Keinert, Kretschmer, Lechler, & Verl, 2014). |

Table 4 – (Continuation) Fundamental Concepts of Industry 4.0

| | |
|---|---|
| **Smart Product** | Smart products are embedded with sensors and microchips which permits communication via the IoT with each other and to carry customer experience and feedback to the supplier. T-shirts, cars, washing powders and among others are becoming "smart" through sensors that labeled into their package by producers. When customer scan the code with smartphone, the code and smartphone can communicate with each other and transaction starts. Unfortunately, this situation poses a personal private problem (Qin et al., 2016). |
| **Smart Vehicle** | Smart Vehicles are Cyber-Physical combined products. They are linked with sensors and the data encompasses driver's operation, vehicles condition, driving route and destination via various types of sensors during the vehicle's operation (Nawa, Chandrasiri, Yanagihara, & Oguchi, 2014). Also, thanks to this connection it is possible that get in touch with driver (Qin et al., 2016). After that, data are uploaded into a local database that has outside database. The outside database is for information that collected from outside of the vehicle. When those data are stable, they are uploaded by drivers and then they are converted into valuable information and public data. The valuable information can address to route prediction for drivers and driving skill analysis (Nawa et al., 2014). |
| **Smart Factory** | Smart factories are intelligent, flexible and dynamic. In smart factories manufacturing is surrounded by sensors and autonomous systems. Process can be improved by machines and equipment via self-optimization and autonomous decision making. (Ivanov, Dolgui, Sokolov, Werner, & Ivanova, 2016). |

Smart factories are places where equipped with smart technologies and provide to communicate for things with each other (Figure 4). Also, they are called as dark factories, because they do not host any person inside. The first smart factory emerged in China in the mobile phone production activity. By using robots, employee number decreases 90% and probability of emergence of defective products decrease from 25% to 5% (Aydin et al., 2017). In smart factories, products can find their ways independently during the process. Although enabling the production to be profitable this new concept introduced new challenges for people who work in those factories (Hofmann & Rüsch, 2017).

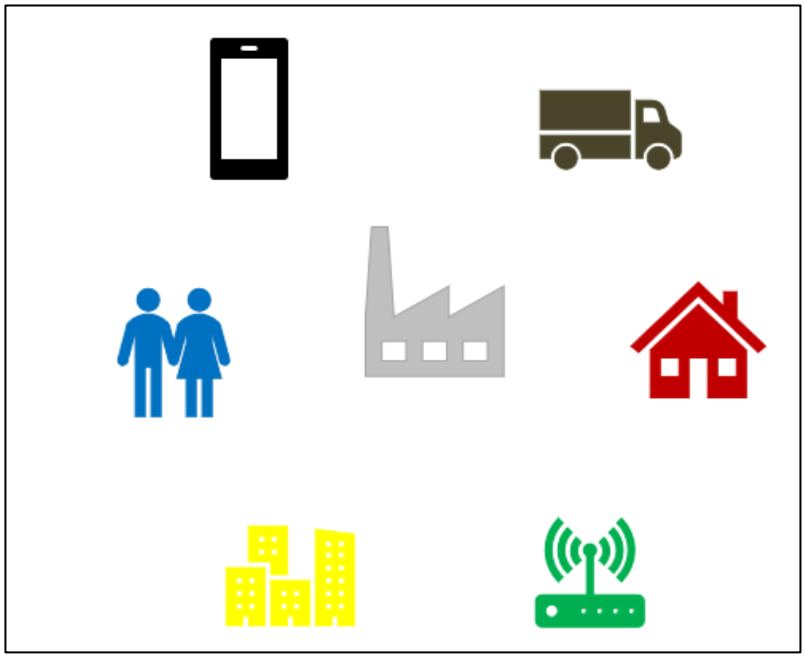


Figure 4 – Smart Factory Illustration

The Technology Initiative SmartFactory$^{KL}$ was developed in 2005 by founding partners from various sectors of economy and research such as; Siemens, Bosch, Pepperl+Fuchs, SAP Research. The main purpose is the development of manufacturing technology. The soap plant is the first action of SmartFactory$^{KL}$ that that produces customizable colour liquid soap bottle. In this factory, customer can choose any colour of liquid soap which is produced without any human interference. The plant is capable to match requirements and demands and then produce the customized colour liquid soaps. The production plant, that laid-out as an integration of several systems controlled by the non-centralized systems, can be considered as the modular structure (Zuehlke, 2010).

Eventually, practitioners are look forward to evaluate industry 4.0 from different perspectives. Particularly understanding important parts and characteristics for analyzing of industry 4.0 in emerging economies and also focusing cyber-physical systems for smart factories (Samaranayake et al., 2017). Industry 4.0

perspective will contribute to new approaches, methodologies and technologies. Industry 4.0 perspective is going to contribute into new approaches, methodologies and technologies. The changeover is not going to be at a fast pace due to high costs and inadequate employees. On the other hand, to properly overcome resistance to change there is need for integration and high connectivity. Although there is an increasing interest among manufacturing industries for implementing and/or transformation to Industry 4.0, it is still a relatively new philosophy and many industry sectors are yet to fully explore and/or commit to transformation to Industry 4.0 at this stage (Benešová & Tupa, 2017; Samaranayake et al., 2017).

### 2.3.2 Quality 4.0

The fourth industrial revolution is occurring today, and it expands the impact of the third revolution and connect it with natural and physical worlds. It connects people, machinery and data through new methods and makes technologies more accessible. For instance, before now 3D printing was used solely by few communities but now it is easier to reach. These technologies are important for quality due to the new approaches towards leadership, collaboration and culture (Jacob, 2017).

The integration and synchronization of procedures in production and processes assurance is the bottom line of "Quality 4.0" as stressed by Gluck, M. (2015) (as cited in Schönreiter, 2017). In fact, Quality 4.0 does not relate with technology but to the users of that technology and the operation also, how this technology develops culture, collaboration, competency and leadership. Quality 4.0 does not replace traditional quality methods, but even better improves and develops them. Despite of this, most of market does not give expected attention to the Quality 4.0 because they are still trying to solve their old problems, such as, inutility caused by broken systems, ineffective supplier communications, etc.

Quality management and Industry 4.0 are expected to activate business profitability, performance, model and innovation through Quality 4.0. Quality 4.0 encompasses the digital transformation of management systems and compliance, furthermore influence of that digitalization on quality technology,

Quality 4.0 concept is very important for the future of quality and practitioners should create add value to Quality 4.0 plan (Jacob, 2017). Quality practitioners should be properly and accurately informed about development in quality management. Each employee in organization should learn about Industry 4.0 and Quality 4.0 terms.

Schönreiter (2017) states that, the readiness of service companies for Quality 4.0 is uncertain for now and for this reason relevant tools and methodologies are required (Schönreiter, 2017).

### 2.3.3 Quality and Social Responsibility

Throughout the recent years, social responsibility (SR) term became a hot topic due to, global emerging changes. Accountability, which is domestic and global, about societal, financial and environmental issues brought forward a consistent interest in social responsibility. Hence, awareness of customers has increased across purchasing of products and services according to the production method. Rather than sustainability and credibility, social responsibility has become a new effective target and "Doing well, by doing good" slogan is adopted by an increasing amount of organizations. Thus, social responsibility has created a new path of doing work (ASQ, 2009; Staiculescu, 2013). Additionally, quality guru Genichi Taguchi stated that "A product or service demonstrates good quality if throughout its production, caused little to no harm to society" (as cited in ASQ, 2009). As understanding from this phrase, he mentioned affinity of social responsibility and quality.

Quality, as a multivariate notion, should conciliate the economic dimension and, at the same time, taking into account societal and environment concerns. According to Staiculescu (2013) social responsibility is a part of the organizational culture of the business. According to Mats Deleryd, CEO & President of Swedish Institute for Quality, the modern definition of quality is changing from "customer satisfaction" to "societal satisfaction" (Deleryd, 2018).

ASQ (American Society for Quality) plays a crucial leadership role to leverage the connection between social responsibility and quality on business. ASQ has more than 90.000 members, both individual and organizations. At the same time ASQ's professional association enhances quality improvement, knowledge interchange and learning to build much better work area and communities around the world. In the 2008 ASQ Futures Study, social responsibility has risen to the second leading force of change in quality and has become a special point of the Malcolm Baldrige National Quality Award Criteria[1].

ASQ (2009) specified some important key drivers for quality and social responsibility;

- New career paths for quality professionals,
- Systematic measurement for sustainable results,
- Operational efficiencies and cost savings,
- Consumer preference for green products and services,
- Regulatory standards focused on ethical behavior.

[1] Malcolm Baldrige National Quality Award Criteria is established by the U.S. Congress in 1987 to enhance awareness of quality management and recognize U.S. companies that have implemented quality management systems successfully (ASQ, 2009; Staiculescu, 2013).

According to Staiculescu (2013) some people have misunderstood that main purpose of the social responsibility, namely, the protection of the environment and the collection of money to solve social problems. To make it clear, experts from the more than 75 countries came together and released ISO 26000: Guidance on Social Responsibility in 2010. ISO 26000 standard is designed to help to both the public and private sectors. Namely, aims to transfer important principles for society's welfare and helps to the organizations to understand a wide array of social responsibility topics. ISO 26000 is not like ISO 9000, there is no specific requirements which organizations must implement, and it is not oriented to certification. ISO 26000 defines the Social Responsibility as; "responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behavior". Social responsibility is not a concept that can be implemented immediately. Conversely is a concept that should include into all levels of execution, planning and stakeholder interaction and is a journey that needs to be lived (ASQ, n.d., 2009; Staiculescu, 2013).

## 2.4 Quality Professionals

To understand how the quality professionals' role is changing, development stages need to be known. Throughout history the role of quality professionals has a great deal. Historical development of Quality Professionals is shown in Figure 5.

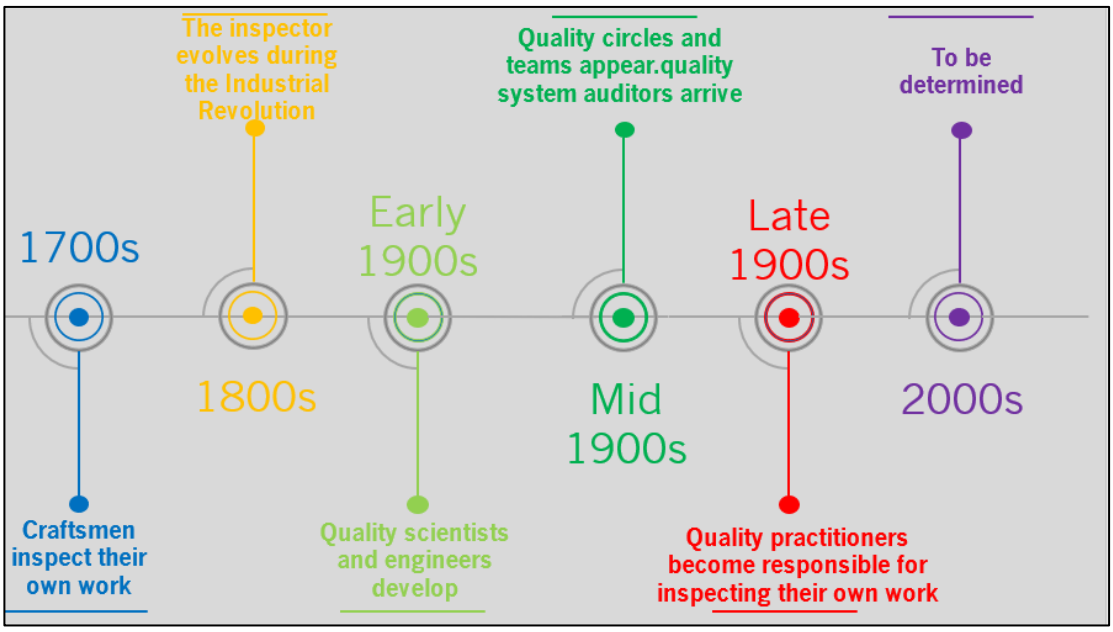



Figure 5 – Changing of Quality Professionals' Role throughout time (Developed by author based on the literature review)

Firstly, quality professionals emerged in manufacturing industry and then they moved into service sector. Currently they are spreading into health and education area. Year in and year out quality professionals found out how to perform new principles, how to change the perspective from 'defect detection' to 'prevent detection' and according to Jim Spichiger the result of this change caused an alteration of titles. For example 'inspector' became 'auditor' (Spichiger, 2002).

Challenges which quality professionals are facing these days also come from this advancement of quality and impact on four primary trends that affect global economy today and in the future as well (Gutner & Adams, 2009).

- Globalization
- Customer sophistication
- Talent management and leadership issues
- Environmental concerns and social responsibility.

Toddi Gutner and Mike Adams identified those trends in The Conference Board's Quality Council;

**Globalization** → Globalization reaches every stage of the business world and has extended influences for quality professionals who command the complex platforms. Beforehand, factories were located nearby raw materials and manpower (enabling to operate machine and tools in the factory). The present situation has changed. They do not dependent from each other like before. However, with progressing world, consumption has increased much more due to huge markets outside the United States and Western Europe, globalization demands that quality professionals act more modernist, collaborative and open-minded for innovation. Thus, to be survivor in this kind of world collaborative innovation has become critical.

**Customer sophistication** → Quality professionals are waiting carefully to take advantage from increased customer expectations to understand who the customer is and what he wants. There are several quality tools such as, quality function deployment, customer surveys and benchmarking to take information from consumers to understand what their expectations are and by these tools, organizations can take advantage.

Additionally, in some companies, quality professionals have moved from the back end to the front end to understand customer and expectations of them.

**Talent management and leadership issues** → Knowledge transfer refers that transmission of knowledge from the most experienced people (in this case baby boomers) to the less experienced people. Knowledge transfer that inside of an organization is a critical factor. Even though the knowledge of person is very important to do job, most of the organizations do not have business strategy plan for knowledge transfer. Sustainable knowledge transfer is complicated activity in the organizations and includes improvement of dynamical processes and the knowledge must play a part in the overall process not in a one person. The most effective way of transmission of knowledge is developing knowledge transfer processes by quality professionals.

**Environmental concerns and social responsibility** → The well-known phrase "doing well by doing good" is became very important for all organizations. Even consumers are requesting ecological approach from companies to purchase their goods and service. Companies started to increase recycled materials using as input, decrease corporate carbon footprints and also applying green innovation techniques (Gutner & Adams, 2009).

Toddi Gutner and Mike Adams stated that "Quality professionals must undertake some actions, such as refreshing and improving customer intelligence, strengthening operational excellence, accelerating the market and understanding customer needs much better. Meanwhile to cope with these challenges they must use proper tools and techniques."

Jim Spichiger is a quality coach for Lucent Technologies Supply Chain Networks, Mt. Olive. He is a Fellow of ASQ as well. He compiled the following survey results in his article titled "The Changing Role of Quality Professionals" (Spichiger, 2002). In 2002, ASQ surveyed a sample of Fellows to collect their insights and perspectives about changing roles of the quality professionals. The survey yielded a 31% response rate. The survey encompassed five open-ended questions. Questions and responses of fellows compiled by Jim Spichiger are shown in Table 5.

Table 5 – Survey Question/Response of ASQ

| Question | Response |
|---|---|
| What does "the changing role of the quality professionals "mean to you? | - Quality professionals are going to be more business-focused and more active in top management.<br>- Quality professionals are going to be ethical business practices' champions.<br>- Quality professionals are going to increase value of organizations. |
| What opportunities exist for quality professionals to offer the benefits of quality to their workplaces, communities and society in general? | - The service and education sectors.<br>- Local, state and federal government, especially with immigration and naturalization. |
| In what specific areas or industries can quality play a more proactive role? | Forty-seven fellows provided 94 responses to this question. Respectively; All, government, service sector, healthcare, education, software, food, finance/accounting. |
| What more can ASQ do to support quality professionals in their changing roles? | Responses about this question are focused on promoting the quality profession. In this case ASQ needs to;<br>- Reach out to top management and disclose the need for quality in all aspects of business,<br>- Promote its success stories,<br>- Get more actively involved in national forums concerning societal problems. |

Jiju Antony published an article (What does the future hold for quality professionals in organizations of the twenty-first century?) that encompassed various perspectives across the future of quality professionals lead by academics and practitioners selected from different countries (Antony, 2013).

→Professor Sung H. Park, Department of Statistics, Seoul National University, Seoul, Korea; Professor Park stated that the future of quality professionals is dependent on the area and mission which the quality

professionals are going to work and handle. Also, he assumed that quality professionals can manage sustainable development and social responsibility issues that are very popular nowadays. Lastly, in order to improve their roles in the future, quality professionals must enlarge their scope of work from classical quality management toward new emerging concepts such as sustainable development and social responsibility.

→Dr. Ronald Snee, Snee Associates, USA; Dr. Ronald said that the world is dynamic and is always changing at the same time quality professionals need to be part of the solution. On the contrary, they will seem like cost and this is un-solicited status. According to Dr. Ronald's thought, if quality professionals handle with continuous improvement, data-based process management systems and listening customers voice, they can improve their organizations and add value. Last words of Dr. Ronald are: "...quality professionals must take a powerful leadership role and to make quality a competitive advantage for organizations."

→Professor S.K. Neogy, Indian Statistical Institute, New Delphi, India; Professor Neogy proposed that, quality professionals should think over about their roles and responsibilities assuming new challenges. In the future, roles of quality professionals should not be only focused on defect and waste reduction, they should also teach, coach and having a high level of interaction with stakeholders and with customers as well. Additionally, statistic will be the essential technology to build a new future for quality professionals.

At the same time Jiju Antony shared his personal thoughts about what roles quality professionals can play in future in this article. These roles are;

- Customer advocates,
- Process excellence experts,
- Investors in sustainable long-term results,
- Innovation leaders,
- Statistical thinkers.

Also, he stated some implications,

Rather than control and improvement, quality professionals are going to show more value creation and innovation activities. They are going to work more closely with customers and suppliers to establish a very effective supply chain. He declared that future of quality professionals must be aware of maintainability, reliability and serviceability of products and also, they should be able to know Lean, Six-Sigma, Systems thinking, Change Management, etc. (Antony, 2013).

## 2.5 Skill and Competence

In a globalized and innovation-based world skill and competence terms are the key words to survive. It is highly important that to understand what changes future will bring, how is going to be different from current time, today, and how people are going to keep step with those changes. To have personal competences and skills are crucial factors in business life to create value. Also, let it be known that competence is very important to convert knowledge into results to increase quality of life.

Ahmad Nabil Nasir and his colleagues (Nasir, Ali, Noording, & Nordin, 2011) wrote an article to explain the concept of non-technical skills which are neglected compared to technical skills. Regarding to their article, they assumed that absence of non-technical skills and high interest to the technical skills is kind of a problem that should be come through by skilled workers. According to this article and literature review that they implemented, non-technical skills refer to generic skills, employability skills and soft skills. Non-technical skills can be obtained with experience and long term practice, not in a short time (Awang, Abidin, Aeshad, Habil, & Yahya, 2006). Non-technical skills divided by two categories. One is functional, the other one is adaptive. Functional skills enable to communicate, analyze and decide. Functional skills are essential skills that used for applying to tasks and to reach the results of the problems. Adaptive skills enable to conduct employees by themselves and affect each other in the working environment.

Technical skills are associated with employee's area about skill, technical competence or expertise. They also known as "hard skills" and they are related with usage area of tools and equipment on work. In comparison with non-technical skills, technical skills are easier to be understand and to be used. Technical skills require a combination of specific knowledge and skills of the work done. In business area, technical skills refer to practical tasks which are easy to quantify, measure and observe. They are specific, tangible and teachable. Medina (2010) assumed that people need to leverage his/her knowledge in his/her area, because business area is changing as well. To obtain the technical skills, there are some ways such as; courses, seminars, technical certification and also internet (Medina, 2010). According to (Nasir et al., 2011), skilled employees are afflicted with not to have non-technical skills. Non-technical skills are essential for skilled employees to make balance on their technical skills. Today, organizations are looking for employees who has integration between technical skills and non-technical skills (Nasir et al., 2011).

Elizabeth A. Cudney and Elizabeth M. Keim wrote an article about summarizing ASQ's research studies conducted in 2016 with American Productivity & Quality Center (APQC) and International Academy for Quality (IAQ). This article recaps those investigations and one part of this article mentioned about "What are the skill gaps in the current quality professionals? What skills do they need to meet business

requirements in the next 10-15 year?" (Cudney & Keim, 2017). From these questions three essential impression were suggested; management/leadership, technical and people (Table 6). In depth, specific components per each impression;

Table 6 – Three essential suggestions based on the Cudney & Keim 2017

| | |
|---|---|
| Management/Leadership | Vision and strategic plan development and deployment, |
| | Communication skills, |
| | General business skills, including accounting/finance and marketing. |
| Technical | Integration of quality systems and technology/IT, |
| | Knowledge management – and process-related learnings, |
| | Critical thinking and analysis – particularly handling big data, |
| | Statistically based process improvement, root cause, and preventive action. |
| People | Culture development and adaptation, |
| | Change management and employee development and coaching-mentoring skills. |

In spite of they could not figure out that there is an agreement about Quality Professionals must master management/leadership, technical and people skills.

Luis Fonseca and Pedro Domingues reported an article "Leading Quality in the 21st Century: Profiles of the Quality and Organizational Excellence Managers" (Fonseca, Domingues, & Sá, 2017) and one of their purpose was to figure out the required competencies and skills for Quality and Organizational Excellence Managers to develop their activities on ISO 9001:2015. According to their classification of competencies and the results; the most important competency is "Knowledge of Culture and Organizational Processes". Next, Quality Systems and Quality Techniques and Tools are also needed competencies. Then, soft skills are considered necessary result of their survey and less importance belongs to the technical skills. In consequence of this research, findings show that, knowledge of culture and organization process and soft skills are going to be focal point.

## 2.6 Research Gaps

Based on the carried out extensive literature review, carried out during this MSc project, the main gap that was found concerns with the scope of the research. This research encompasses a worldwide survey. The survey was released worldwide, and the responses originated from more than 60 countries and include 6 macro regions (Europe, North America, Middle-East, Central/South America, Africa and Asia). According to literature review that adopted by authors, there is no similar study that encompasses such a wider sample.

Based on the literature review, several studies have been reported but none of them mentioned specifically importance of skills in detail and dimension by dimension.

According to the current literature, several studies have been reported but none of them includes analysis based upon grouping variables to explain difference of the expressions. Throughout this research, some common thoughts may be explained according to some grouping variables such as, macro region, organization role, experience year.

In addition to this, in terms of respondents of the survey, this research encompasses wide range of respondents from different organization role and analyses were carried out in between those organization role groups.

## 3. RESEARCH METHODOLOGY

Consistent research results are strongly dependent on the way research methodology is designed, defined and established and on how the methods implemented are carried out. Throughout this research study on *The Profile of the Quality Professionals of the 21st Century* a mixed method (quantitative and qualitative) approach was adopted. Mixed method includes both quantitative and qualitative analyzing methods. Raw quantitative data, according to (Saunders, Lewis, & Thornhill, 2008) is not very meaningful and, usually, it is transformed into graphs, charts and statistics to be more meaningful and helpful. On the other hand, qualitative data (non-numeric data) needs to be analyzed aiming at a properly understanding of its true meaning. The analysis of qualitative data enables the development of new theory from it (Saunders et al., 2008). The research methodology adopted throughout this study was supported in a descriptive/exploratory approach aiming at defining the profile of the quality professionals of the 21st Century. The raw data was collected by surveying Quality Professionals, Quality Managers, Consultants both individually and company-based. At a first stage, the survey was held online throughout two weeks in May 2018 yielding 146 responses. Then, till July the number of responses reached 195. At the beginning of September, the total number of responses was 315. Figure 6 displays the main steps of the study carried out in this project are structured.

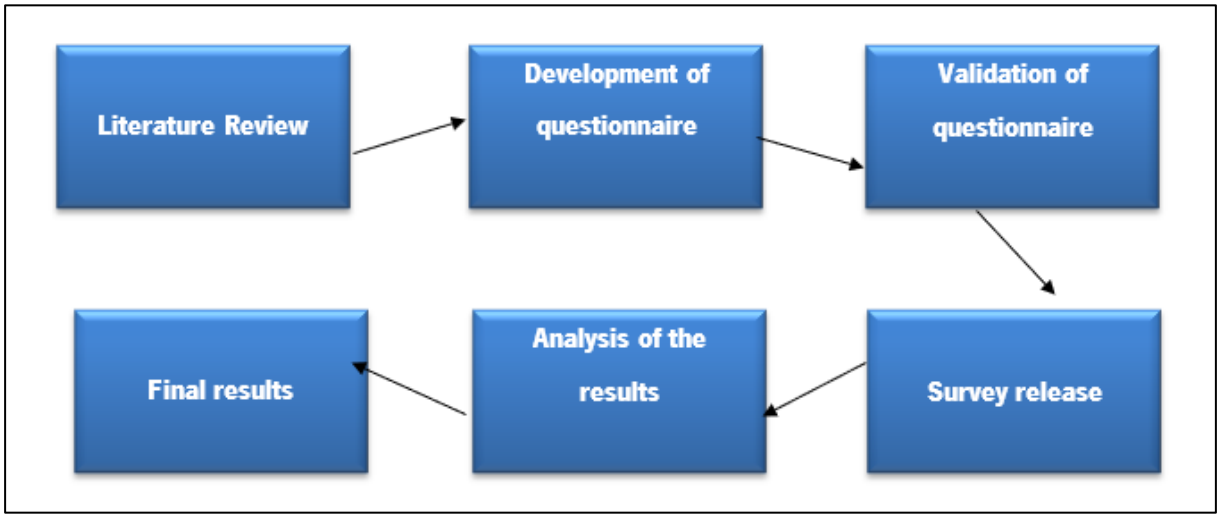
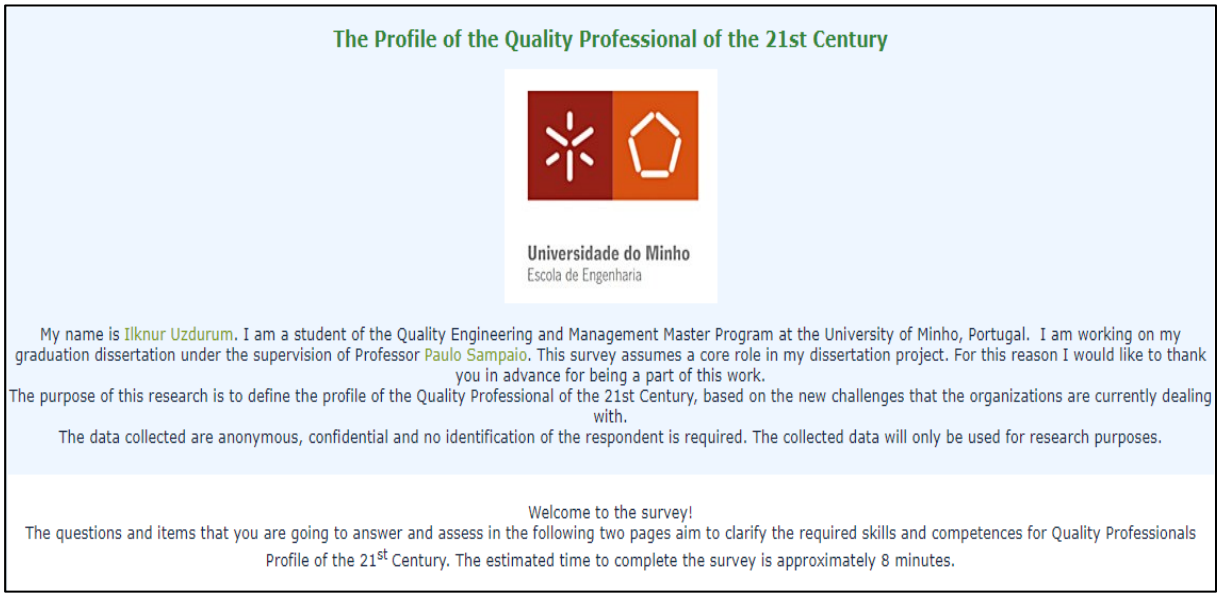



Figure 6 – Simulated scheme of the steps implemented in the research methodology

In the first step of the research (Literature Review), a comprehensive literature review was carried out addressing the new concepts that revolve around the quality domain, such as, Industry 4.0 (I 4.0), Quality 4.0, quality and social responsibility, quality professionals, skills and competences. Additionally, the soundest papers and books addressing the topics of survey design and data analysis were identified.

The "Development of questionnaire" stage encompassed the questionnaire-online survey designed, conception and development. According to (Saunders et al., 2008), questionnaires are one of the largely used data collection techniques due to accessibility to a large number of people and due that each respondent is asked to answer to the same set of questions. In addition, fast response time was critical for selecting this technique. The literature review pointed out several skills dimensions that were sectioned into 5 groups: 1- Technical Skills, 2- Soft Skills, 3- Leadership Skills, 4- Management Skills and 5- Analytical Skills. For the purpose of this research, the platform provided by University of Minho – Lime Survey was used to develop the online questionnaire. The opening form of the online survey (Figure 7) encompasses generic information such as who conducts survey, a brief explanation of the purpose of the questionnaire, the total expected time of response and the privacy statements (anonymity and confidentially of answers was ensured).


The Profile of the Quality Professional of the 21st Century

Universidade do Minho
Escola de Engenharia

My name is Ilknur Uzdurum. I am a student of the Quality Engineering and Management Master Program at the University of Minho, Portugal. I am working on my graduation dissertation under the supervision of Professor Paulo Sampaio. This survey assumes a core role in my dissertation project. For this reason I would like to thank you in advance for being a part of this work.
The purpose of this research is to define the profile of the Quality Professional of the 21st Century, based on the new challenges that the organizations are currently dealing with.
The data collected are anonymous, confidential and no identification of the respondent is required. The collected data will only be used for research purposes.

Welcome to the survey!
The questions and items that you are going to answer and assess in the following two pages aim to clarify the required skills and competences for Quality Professionals Profile of the 21st Century. The estimated time to complete the survey is approximately 8 minutes.

Figure 7 – Opening form of the online survey

The survey structure comprised two sections. Section 1 encompassed 11 questions (both individual and company based) intended to ascertain the profile of the respondents. Section 2 was sectioned into two parts. First part included specific questions encompassing 27 expressions addressing the most relevant competencies of the Quality Professionals and second part encompassed three open-ended questions

each of them asking the respondents' opinions regarding current skills of Quality Professionals and quality tools (Attachment I).

Quantitative analysis of data was carried out both in section 1 and first part of section 2. Statistical analysis of section 1 and first part of section 2 was carried out through IBM SPSS v.25 software. In section 1 was adopted a semi-structured approach (mostly multiple-choice questions and one open ended question). The first part of section 2 encompassed structured five-point Likert scale (Importance) questions aiming at the evaluation of the 27 expressions. The Five-point Likert scale consisted ranged from: Unimportant (1) to Extremely Important (5) (Figure 8).

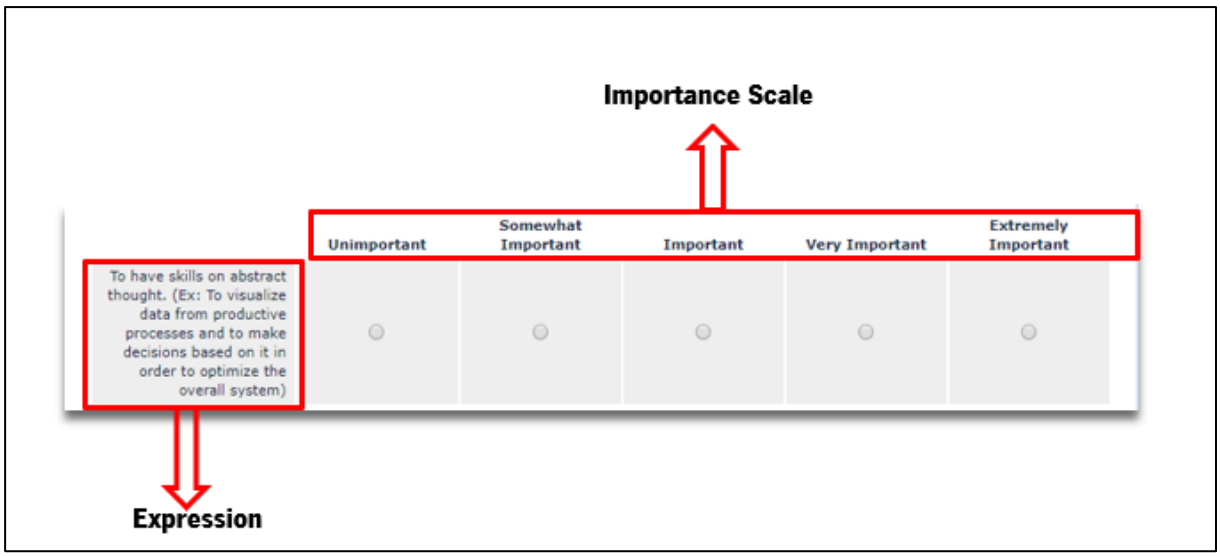



Figure 8– Five-point Likert Scale illustration

The first dimension assessed concerned with Technical Skills. Technical Skills encompassed five expressions evaluated by the respondents according to the previous mention Likert importance scale. The expressions assessed were:

- Being abstract thought, mainly data visualization,
- Being capable on Industry 4.0 area, mainly smart systems, technological devices, Quality 4.0 and Big Data,
- Being expert in Quality Control Tools, Quality Management Tools and Continuous Improvement Tools,
- Being expert troubleshooting techniques, mainly maintenance, repair, operation & control,
- Being able to work with Information Technology tools, mainly Visual programming, interaction with digital interfaces.

The second dimension assessed (Soft Skills) encompassed 11 expressions to be evaluated. Soft skills relate mainly to intrinsic personal skills.

- To have emotional intelligence,
- To be persuasive,
- To be creative and innovative,
- To be altruistic, mainly social and environmental awareness, volunteer work,
- To be team worker,
- To be ambitious, open-minded, continuous learner,
- To be able to create social network,
- To be capable to solve complex problems,
- To be able to adapt into changing roles in business,
- To have cognitive flexibility,
- To be a good communicator, such as good listener and writer adopting the proper language.

Leadership skills (3rd Dimension) express those required skills that proxy leadership skills in the business life. In this dimension 7 expressions were considered:

- To be instructive, assistant and able to point out alternatives and new paths,
- To encourage and motivate employees,
- To be in touch and coordinative with all departments,
- To be able to delegate,
- To be fair and objective,
- To be capable to moderate difficulties,
- To be capable to congratulate, to punish and to reward employees at the proper occasion.

Management skills (Fourth Dimension) encompassed two expressions;

- To be aware and attentive towards the needs and expectations of the customer,
- To have good management skills, mainly human resources, financial resources, material resources, risk, time and conflict management.

The 5th dimension aimed at the assessment of the "Analytical Skills" (Some authors call it "Numeracy Skills") (Dr. Shirley Coleman obtained from (Antony, 2013). The following expressions aimed at the assessment of these dimensions:

- To be good at analytical and mathematical reasoning, data mining and text analytics,
- To be capable of properly adopt the suitable statistical tools and methodologies.

The final part of section 2 considered three open-ended questions. In this part unstructured data collection approach was adopted. Respondent's answers were clustered on an Affinity Diagram. These questions aimed at finding out a more detailed perspectives from the respondents regarding the following topics: generic expectations regarding next generation of Quality Professionals, quality tools adequacy to face the new industry challenges, the missing skills of Quality Professionals (those skills not addressed in this survey) and the most important skills in the near future. Hence, the following questions comprised the last part of the survey aiming at bringing light towards the above-mentioned issues.

- What are your expectations concerning the Quality Professionals of the 21st Century based on their ability, knowledge and personal characteristic? (Please point out abilities that were not mentioned on the previous questions).
- Do you think that the current quality tools are sufficient to deal with the new industry challenges? If your answer is no, could you please explain why?
- Which quality tools may be combined in order to gain maximum resilience to face the new industry challenges?

Prior holding the survey online a pilot test was carried out among three experts in the quality area and by five practitioners (selected from Quality and Organizational Excellence group of University of Minho, Braga) (Lopes, Nunes, Sousa, & Esteves, 2011). The survey was analyzed by group members and supported on their insights some changes were introduced aiming at the improvement of the survey.
Upon the validation of the questionnaire, an e-mail encompassing the survey link, was sent to all respondents. All quantitative data were analyzed by IBM Statistical Package for the Social Sciences (SPSS Statistics) version 25. Numerical transformation of the variables is shown in Attachment II.

## 4. Result Analysis and Discussion

The analysis of the data collected from the online survey is presented in the following pages. An international survey was held online yielding 329 answers (315 validated answers). A total of 14 answers were discarded due to incompletion of the questionnaire. Figure 9 summarizes the different stages of the results analysis carried out.

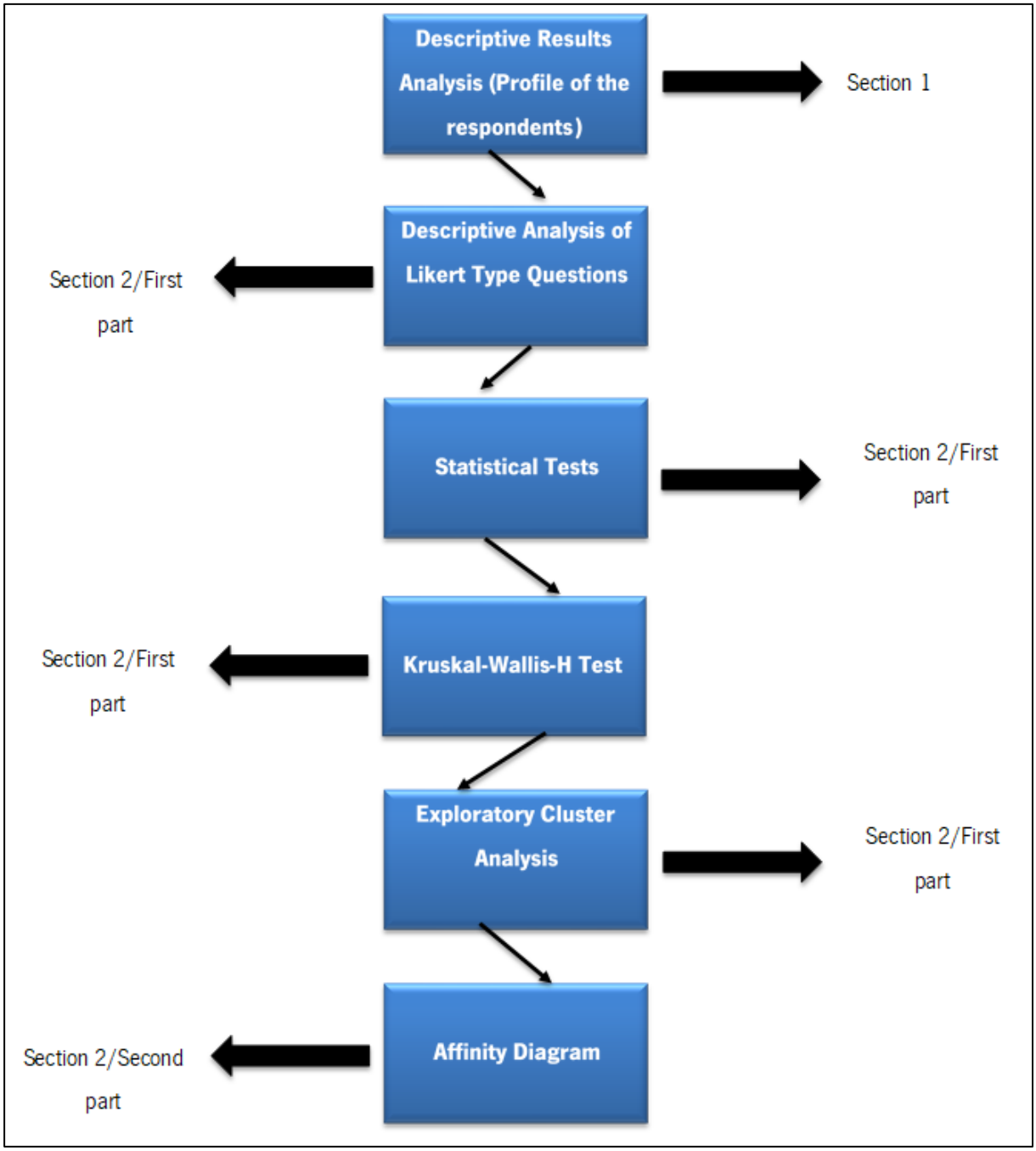



Figure 9 – Research's analysis summary

## 4.1 Descriptive Results Analysis

### 4.1.1 Profile of the respondents

Figures 10 to 16 summarize the profile of the set of respondents. A total of 315 validated answers were considered (73.9% male respondents).

Figure 10 displays the different geographic locations of the respondents. The countries which accounted for the highest amount of answers (countries top five) were Portugal (54), United States (54), Brazil (40), Spain (11) and Hungary (11).

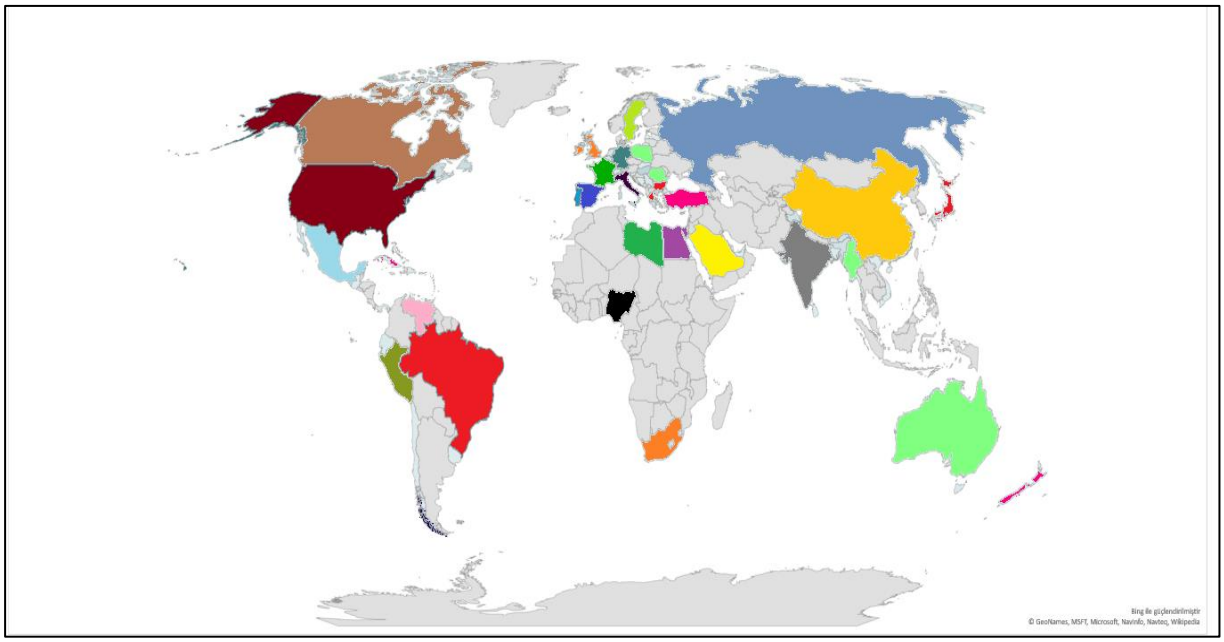


Figure 10 – Distribution of respondents: Breakdown by geographic

Figure 11 presents the histogram of respondents age (Minimum-23, Maximum-89). Higher than 50% of the respondents have between 35 and 59 years. Respondents with less than 35 or higher than 71 years account for less than 20% of the sample.

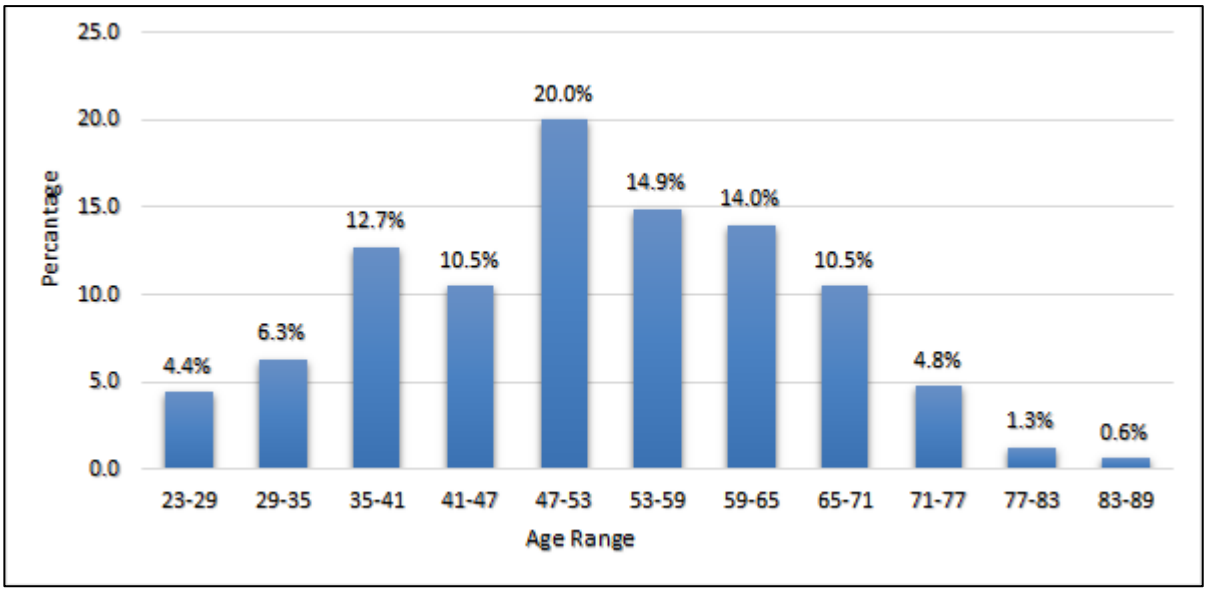



Figure 11 – Distribution of respondents: Breakdown by age range

Mainly highly experienced respondents answered the survey. A great deal of the respondents (64%) hold more than 15 years' experience in the quality field (Figure 12). Less than 15% of the respondents hold less than 5 years of experience in the quality field.

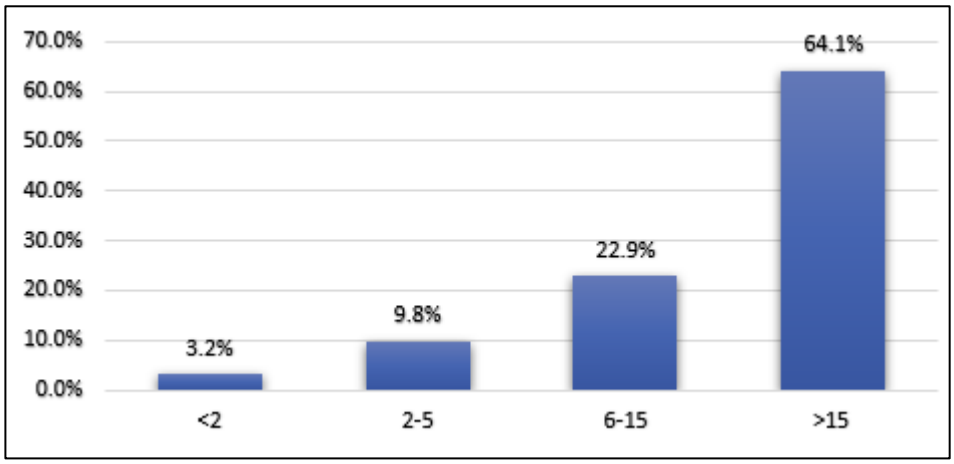



Figure 12 – Distribution of respondents: Breakdown by experience (nº of years)

Concerning activity sectors where respondents carry out their activities it should be pointed out the industry sector (38.4%), the education sector (22.2%), the service sector (21%), the healthcare sector (3.2%) and the social sector (0.3%). Other option (which includes consultancy, energy and environment, food, government sectors) accounted for 14.9%. The relative distribution of respondents: breakdown by activity sector is presented Figure 13.

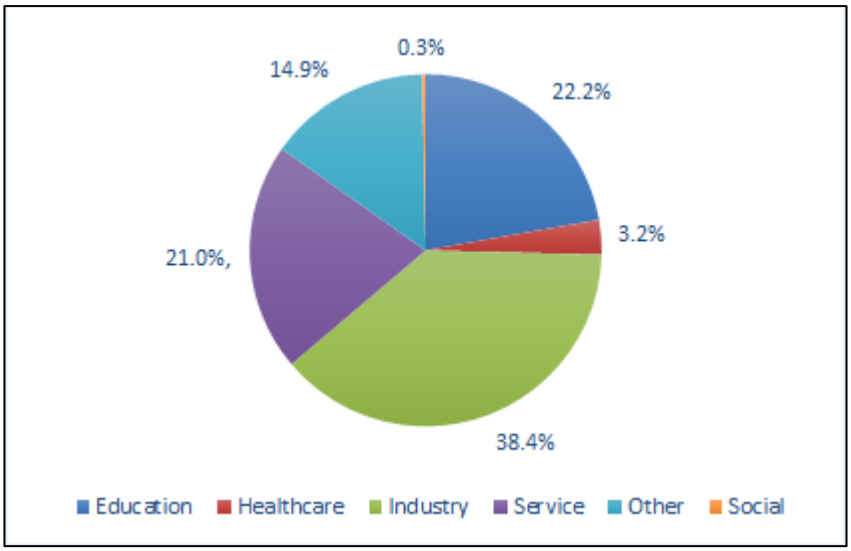



Figure 13 – Distribution of respondents: Breakdown by activity sector

Regarding the dimension of the companies where respondents operate a great deal (65.7%) are very large (>501 employees) companies (43.5%) or large (between 51-500 employees) companies (22.2%). 34.3% of the respondents develop their activities in SMEs (50 and less than 50 employees.) The distribution of respondents by dimension is illustrated in Figure 14.

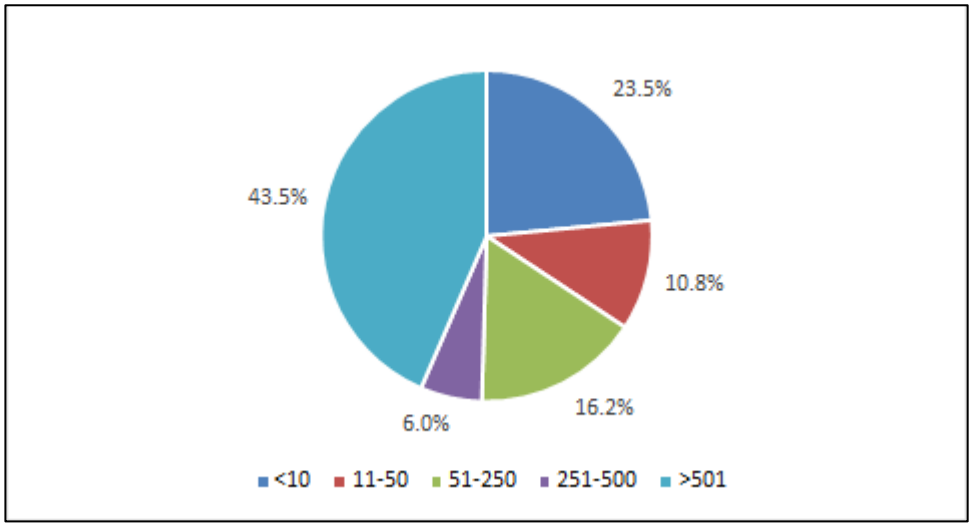



Figure 14 – Distribution of respondents: Breakdown by dimension of the company (nº of employees)

Regarding the percentage of activity of each company in international market results show that most of the organizations (35.6%) have more than 25% activity focused on the international market. Conversely, a remarkable amount of companies (29.2%) have less than 2% of activity focused on the international market. Figure 15 represents the distribution of respondents by activity in the international market.

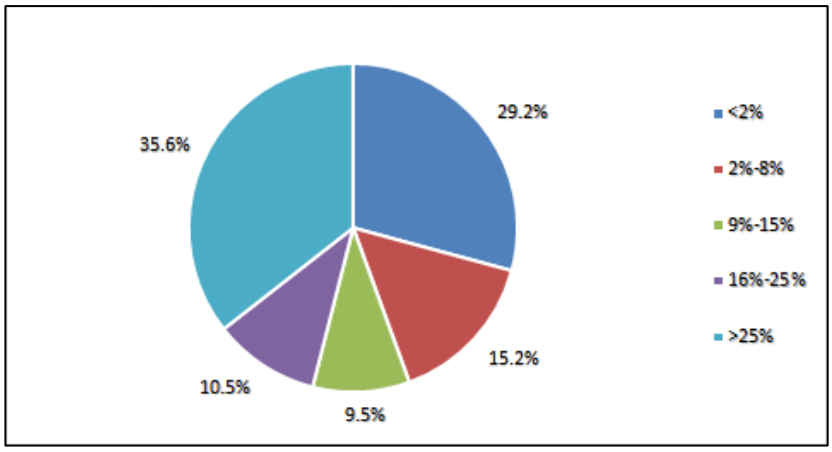



Figure 15 – Distribution of respondents: Breakdown by activity in the international market

According to the organizational active roles (Figure 16) results suggest that the majority of the respondents (circa 70%) are closely related to the business context and 16.5% are closely related to academy (Professors). In addition, the "Other" option (which includes analyst, auditor, industrial engineer, process engineer and vice president (VP)) accounted for nearly 14%.

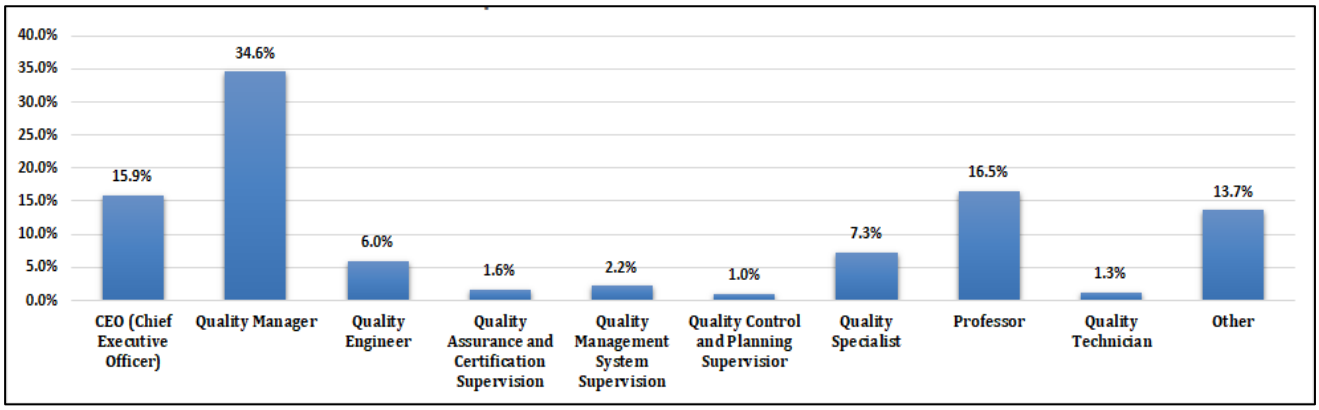



Figure 16 – Distribution of respondents: Breakdown by their active organizational role

### 4.1.2 Overall Descriptive Analysis of Likert Type Questions

The importance level (perceived by respondents) was summarized according to the mean of the results (by item and by dimension) in Table 7. All dimensions were considered important and relevant (mean above 3) by respondents. The results suggest that the most relevant and important dimension is "Management Skills" (mean value 4.31) and the less important dimension is "Analytical Skills" (mean value 3.71). Each skill dimension is analyzed in more detail in the following subsections.

Table 7 – Importance levels of overall dimensions

| Dimensions | Expressions | Mean | Mean (by dimension) | Std. Deviation | Analysis N |
|---|---|---|---|---|---|
| Technical Skills | Being abstract thought | 4.1651 | 3.78 | .78484 | 315 |
| | To be expert on Industry 4.0 | 3.4952 | | .95894 | 315 |
| | Being expert of quality tools | 4.1492 | | .84835 | 315 |
| | Being expert of troubleshooting | 3.4825 | | 1.02307 | 315 |
| | To be able to work with IT tools | 3.6413 | | .95181 | 315 |
| Soft Skills | To have emotional intelligence | 3.9778 | 3.99 | .86482 | 315 |
| | To be persuasive | 3.9238 | | .87821 | 315 |
| | To be innovative | 4.1048 | | .81300 | 315 |
| | To be altruistic | 3.3206 | | 1.04457 | 315 |
| | To be able to work with team | 4.4635 | | .70560 | 315 |
| | To be ambitious | 4.1397 | | .79780 | 315 |
| | To be able to create social network | 3.3365 | | 1.03802 | 315 |
| | To be expert of complex problem solving | 3.9206 | | .88335 | 315 |
| | To be able to adapt into changing roles | 4.1079 | | .78263 | 315 |
| | To have cognitive flexibility | 4.2286 | | .71726 | 315 |
| | To be a good communicator | 4.4063 | | .77375 | 315 |
| Leadership Skills | To be instructive | 4.0095 | 4.07 | .76752 | 315 |
| | To motivate workers | 4.1397 | | .82912 | 315 |
| | To be coordinative with all departments | 4.1302 | | .79742 | 315 |
| | To be able to delegate | 3.9524 | | .89990 | 315 |
| | To be fair and objective | 4.2825 | | .71795 | 315 |
| | To be able to moderate difficulties | 4.1619 | | .72433 | 315 |
| | To be able to congratulate | 3.8730 | | .91853 | 315 |
| Management Skills | Being customer focused | 4.5206 | 4.31 | .68797 | 315 |
| | To have good management skills (time management, risk management etc.) | 4.0984 | | .74001 | 315 |
| Analytical Skills | To be good at analytical reasoning | 3.6921 | 3.71 | .84674 | 315 |
| | To be capable to adopt statistical tools | 3.7333 | | .84763 | 315 |

### 4.1.3 Technical Skills

The summarized results regarding the "Technical Skills" dimension are presented in Figure 17. The most important perceived skill is "To be able of abstract thought" (mean value 4.16). According to the same results, the less important perceived skill is "Being expert of troubleshooting" (mean value 3.48). Also, "Being expert of troubleshooting" and "To be expert on Industry 4.0" (mean value 3.49) are close to each other in regard to their mean values.

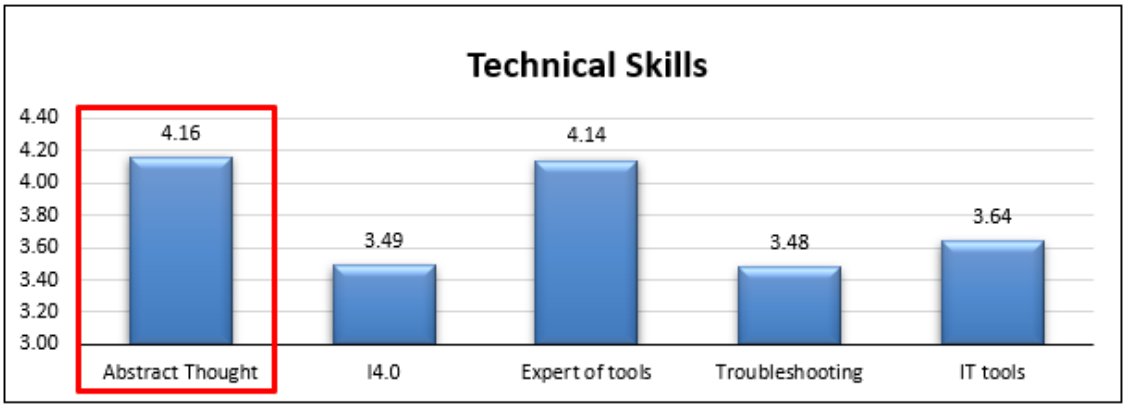



Figure 17 – Importance level of Technical Skills

### 4.1.4 Soft Skills

The summarized results of the "Soft skills" dimension (Figure 18) suggest that the most important perceived skill is "To be able to work with team" (mean value 4.16). The least important skills seem to be "To be altruistic" (mean value 3.32) and "To be able to create social network" (mean value 3.33).

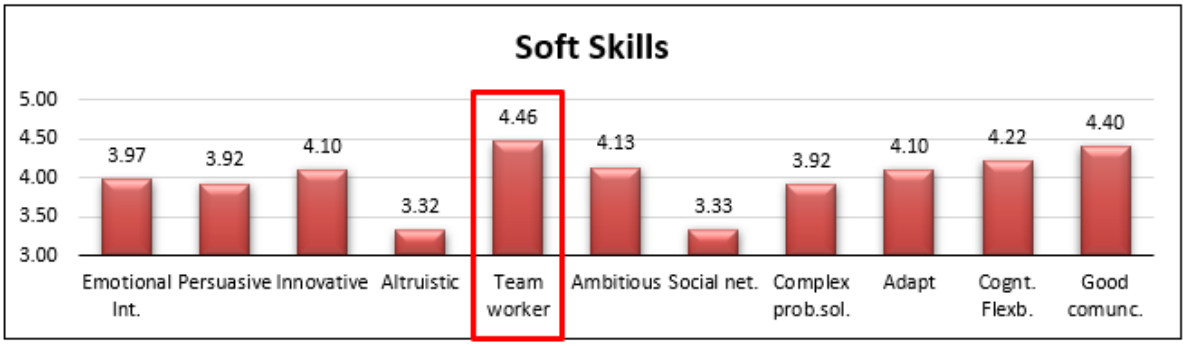



Figure 18 – Importance level of Soft Skills

### 4.1.5 Leadership Skills

Figure 19 presents the summarized results from the "Leadership skills" dimension. According to Figure 19, "To be fair and objective" is perceived as the most important skill (mean value 4.28). Conversely, "To be able to congratulate" seems to be the least important skill.

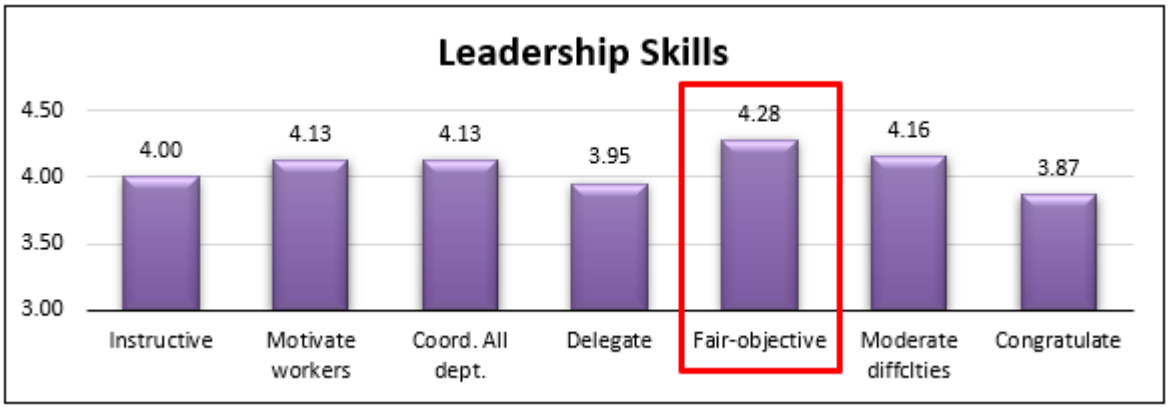



Figure 19 – Importance level of Leadership Skills

### 4.1.6 Management Skills

As previously stated, "Management skills" dimension is perceived as the most important dimension (the summarized results are presented in Figure 20). The most important perceived particular skill is "Being customer focused" (mean value 4.52) and "To have good management skills (time management, risk management etc.)" (mean value 4.09) was evaluated as the least important skill in this dimension.


Figure 20 – Importance level of Management Skills

### 4.1.7 Analytical Skills

As previously stressed, the least important dimension was "Analytical skills". The breakdown of results by assessed item is presented in Figure 21. "To be capable to adopt statistical tools" skill (mean value 3.73) was perceived the most important skill within this dimension. Conversely, "To be good at analytical reasoning" (mean value 3.69) skill was considered the least important skill in this skill dimension and in the overall skill dimensions as well.

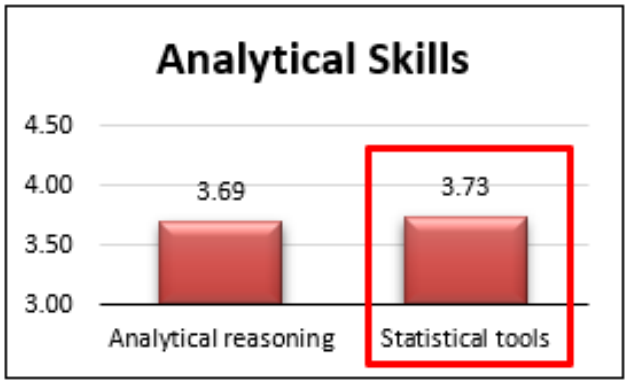



Figure 21 – Importance level of Analytical Skills

## 4.2 Statistical Tests

Aiming at deepening the quantitative analysis several statistical tests were conducted. Considering the exploratory approach adopted in this study it was considered a significance level of 0.1. Kolmogorov-Smirnov and Shapiro-Wilk test were adopted to assess the normality of data (Khrueasom & Pongpullponsak, 2017). Results suggest that data are not normally distributed (p-value<0.1) entailing non-parametric methodologies should be adopted in next steps.

## 4.3 Reliability Analysis

To measure consistency of survey answers, reliability analysis was carried out by Cronbach's Alpha coefficient. Cronbach's Alpha is a technique that estimates reliability of given data set (Gliem & Gliem, 2003). Cronbach's Alpha coefficient ranges between 0 and 1. Value as long as close to 1, it shows that internal consistency of item is greater. George and Mallery (2003) (adopted from (Gliem & Gliem, 2003)) assumed that the scale as if the Cronbach's Alpha is;

- Greater than 0.9 → Excellent
- Greater than 0.8 →Good

- Greater than 0.7 →Acceptable
- Greater than 0.6 →Questionable
- Greater than 0.5 →Poor
- Less than 0.5 →Unacceptable

From this point of view, authors adopted an acceptable Cronbach's Alpha as greater than 0.7. Cronbach's Alpha of existent data set was calculated 0.901 (Table 8) by using SPSS and this value explains that, according to George and Mallery's assumption, data set has excellent Cronbach's Alpha value.

Table 8 - Reliability Statistics of data set of the survey

| Reliability Statistics | | |
|---|---|---|
| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
| .901 | .904 | 27 |

## 4.4 Kruskal-Wallis-H Test

Kruskal-Wallis test is the most appropriate test to implement concerning non-parametric data sets. Kruskal-Wallis test assesses the significance of the differences between three or more grouping variables (Ostertagová, Ostertag, & Kováč, 2016). In this thesis, selected grouping variables are; macro region, respondent's experience year and respondent's organizational role. Table 9 presents the assessment of difference of the Technical Skills Dimension based on the organizational role grouping variable. A new Kruskal-Wallis notation and improved visualization is presented for the first time in this thesis (Figure 22). Each circle symbolizes one asymptotic sigma value. Difference level of variables is decreasing from inside to outside. This means that, if the variable score closes to the middle (p-value<0.1) of the circle, then, the variable differs according to the grouping variable. Results in table 10 and Figure 22 suggests that assessment of the variables differ according to respondents' organizational roles. 2 hypotheses were defined.

$H_0$ = There are no statistical difference

$H_1$ = There are statistical difference

In this thesis, ascribed significance level determined as 0.1, for this reason if asymptotic sigma value of variable is less than 0.1, then $H_0$ hypothesis is rejected. Table 9 presents the Kruskal-Wallis test results by adopting respondents' organization role as first grouping variable and Table 10 presents situations of variables regarding to $H_0$ – $H_1$ hypothesis.

Table 9 – Kruskal-Wallis Test of Technical Skills Dimension by Respondents' Organization Role

| Test Statistics[a,b] | | | | | |
|---|---|---|---|---|---|
| | Being abstract thought | To be expert on Industry 4.0 | Being expert of quality tools | Being expert of troubleshooting | To be able to work with IT tools |
| Kruskal-Wallis H | 5.749 | 12.850 | 5.502 | 9.997 | 17.640 |
| df | 9 | 9 | 9 | 9 | 9 |
| Asymp. Sig. | .765 | .170 | .789 | .351 | .040 |
| a. Kruskal Wallis Test | | | | | |
| b. Grouping Variable: Num_Org_Role | | | | | |

Table 10 – Hypothesis Table

| Variables | Asymp.Sig. | |
|---|---|---|
| Being abstract thought | .765 | → Accept null hypothesis |
| To be expert on Industry 4.0 | .170 | → Accept null hypothesis |
| Being expert of quality tools | .789 | → Accept null hypothesis |
| Being expert of troubleshooting | .351 | → Accept null hypothesis |
| To be able to work with IT tools | .040 | → Reject null hypothesis* |

* According to Table 10, "To be able to work with IT tools" variable differs according to Respondents' organizational role.

"To be able to work with IT tools" skill is positioned in the middle of 0.05 asymptotic sigma value circle (Figure 22). This situation shows that "To be able to work with IT tools" skill differs according to the respondents from different organizational role. Other variables are positioned outside of the 0.1 asymptotic sigma value circle, so, they do not differ according to the respondents from different organizational role.

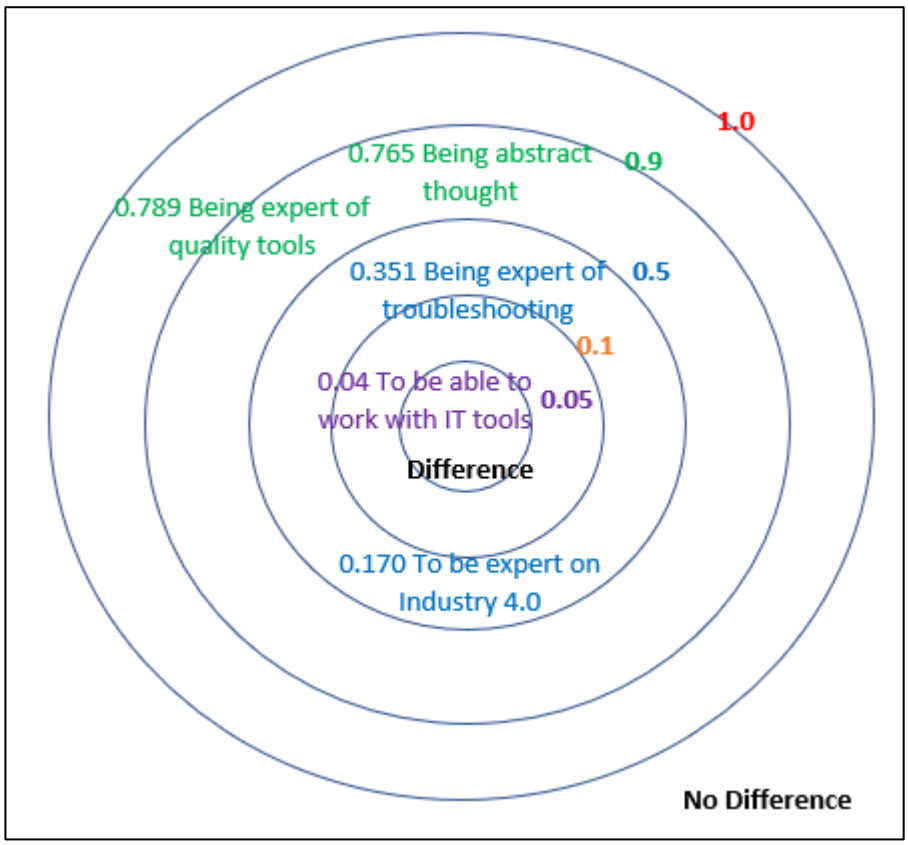



Figure 22 – Kruskal-Wallis statistical test (Technical Skills)

Theoretical models assume that independent variables have an impact on dependent variables in the behavioral science (Judd, 2015). A moderator variable is a variable that has a potential to effect on the intensity of the relationship between dependent and independent variables. In this case, respondents' organizational role, macro region and respondents' experience year may be considered as moderator variables, because the importance levels of expressions are statistically different according to the grouping (moderator) variables (Table 11).

The Kruskal-Wallis test was adopted on each dimension by adopting three different grouping variables. Summarized results are shown in Table 11. The check symbol (✓) represents a situation which the alternative hypothesis ($H_1$) was accepted and the cross symbol (X) represents a situation which null hypothesis ($H_0$) was accepted (Domingues, Arezes, & Sampaio, 2017).

Table 11 – Kruskal-Wallis statistical test results on each dimension

| Dimension | Grouping Variables / Expressions | Respondents' organizational role | Macro Region | Respondents' experience year |
|---|---|---|---|---|
| TECHNICAL SKILLS | Being abstract thought | X | ✓ | X |
| | To be expert on Industry 4.0 | X | X | X |
| | Being expert of quality tools | X | ✓ | X |
| | Being expert of troubleshooting | X | X | X |
| | To be able to work with IT tools | ✓ | ✓ | X |
| SOFT SKILLS | To have emotional intelligence | ✓ | X | X |
| | To be persuasive | ✓ | X | X |
| | To be innovative | X | X | X |
| | To be altruistic | ✓ | X | X |
| | To be able to work with team | X | ✓ | X |
| | To be ambitious | X | X | X |
| | To be able to create social network | X | X | X |
| | To be expert of complex problem solving | X | ✓ | X |
| | To be able to adapt into changing roles | X | X | X |
| | To have cognitive flexibility | X | X | X |
| | To be a good communicator | ✓ | X | ✓ |
| LEADERSHIP SKILLS | To be instructive | ✓ | ✓ | X |
| | To motivate workers | X | ✓ | X |
| | To be coordinative with all departments | ✓ | X | ✓ |
| | To be able to delegate | X | X | X |
| | To be fair and objective | X | X | X |
| | To be able to moderate difficulties | X | X | X |
| | To be able to congratulate | X | X | X |

| | | | | |
|---|---|---|---|---|
| MANAGEMENT SKILLS | **Being customer focused** | X | X | ✓ |
| | **To have good management skills (time management, risk management etc.)** | X | X | X |
| ANALYTICAL SKILLS | **To be good at analytical reasoning** | ✓ | ✓ | X |
| | **To be capable to adopt statistical tools** | X | ✓ | X |

## 4.5 Exploratory Cluster Analysis

Cluster analysis is a data mining technique that identifies groups of samples that have similar features in the data sets. In case of information absence about data's sort and to predict about community, cluster analysis is useful technique (Yilmaz & Patir, 2011). In this thesis, hierarchical cluster analysis technique was used by using SPSS. For cluster analysis, solely selected countries were considered (5 or more than 5 respondents). First, some statistical calculations were carried out in excel such as; mean, standard deviation, median, kurtosis, skewness of the variables. These summarized statistical results were used to set up cluster analysis in SPSS.

In cluster analysis, the distance between variables is considered throughout the generation of groups. The distance shows similarity and proximity of the groups with each other. In this case, if the countries are similar to each other, similarity measurement needs to be high and the distance measurement needs to be low. According to (Gurbuz & Karabulut, 2009), squared Euclidean distance is the most common indicator and same indicator was obtained in this thesis as well.

Countries were represented by numbers in Table 12 – Table 13.

Brazil → 1

Canada → 2

Germany → 3

Spain → 4

U.K → 5

Hungry → 6

India → 7

Italy → 8

Mexico → 9

Portugal → 10

U.S.A → 11

The most alike countries are evaluated by using coefficients in the agglomeration schedule. The results are shown in Table 12. According to result of this method the most alike countries (1.593) are Brazil and Portugal. In the second rank (2.845) there are Brazil and Spain. The less alike countries are Brazil and India.

Table 12 – Agglomeration Schedule

| Agglomeration Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Stage | Cluster Combined | | Coefficients | Stage Cluster First Appears | | Next Stage |
| | Cluster 1 | Cluster 2 | | Cluster 1 | Cluster 2 | |
| 1 | 1 | 10 | 1,593 | 0 | 0 | 2 |
| 2 | 1 | 4 | 2,845 | 1 | 0 | 3 |
| 3 | 1 | 6 | 4,650 | 2 | 0 | 5 |
| 4 | 2 | 11 | 4,930 | 0 | 0 | 5 |
| 5 | 1 | 2 | 6,764 | 3 | 4 | 6 |
| 6 | 1 | 5 | 8,051 | 5 | 0 | 7 |
| 7 | 1 | 8 | 9,428 | 6 | 0 | 8 |
| 8 | 1 | 3 | 11,918 | 7 | 0 | 9 |
| 9 | 1 | 9 | 13,268 | 8 | 0 | 10 |
| 10 | 1 | 7 | 27,770 | 9 | 0 | 0 |

At the same time, dendrogram method was applied to show hierarchical cluster results. Dendrogram scaled from left to right 0-25 unit. Distance between units are equal. Horizontal lines show distance, vertical lines show matched sets. When examined dendrogram that used to show hierarchical cluster results, the most alike countries are creating group in a 1-unit distance, the less alike countries are creating group in 25-units distance that take part in the last rank. Similarity between Brazil and Portugal is very strong, for this reason these countries were created group in a 1-unit distance. Brazil and Spain are also similar to each other, but they came together in 2-units distance. Hungry joined group of Brazil – Spain in 3-units distance. Canada and U.S.A were created a group in 4-units distance. At the same time, Canada joined Brazil – Spain – Hungry group in 5-units distance. Then, U.K joined Brazil – Spain

– Hungry – Canada group in 7-units distance. Next, Italy joined to the new group (Brazil – Spain – Hungry – Canada – U.K) in 8-units distance. After that, Germany joined to the new group (Brazil – Spain – Hungry – Canada – U.K – Italy) in 10-units distance. Mexico also joined to the new group (Brazil – Spain – Hungry – Canada – U.K – Italy – Germany) in 12-units distance and last group is created by joining of India into the (Brazil – Spain – Hungry – Canada – U.K – Italy – Germany – Mexico) group in 25-units distance (Figure 23).

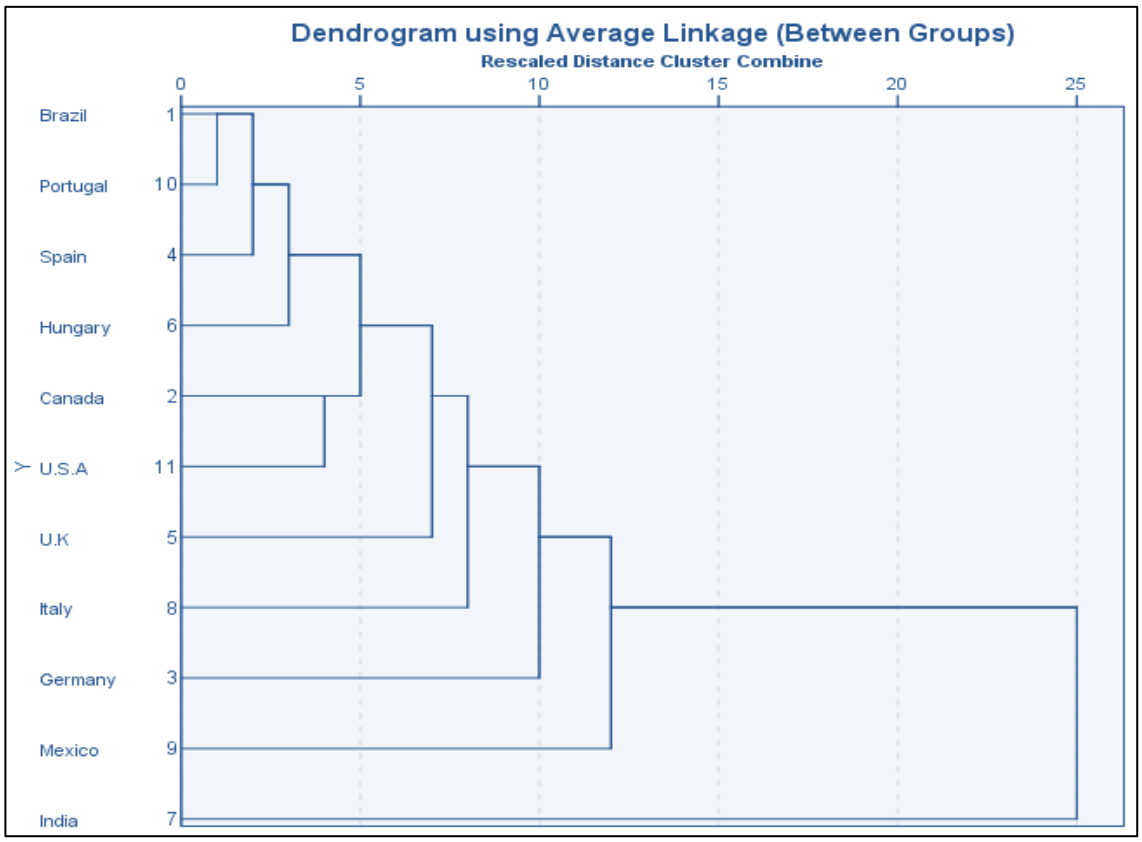



Figure 23 - Dendrogram

In the proximity matrix, difference between countries is shown by using dissimilarity coefficient matrix. According to coefficients, the most unlike (40.549) countries are Mexico – India. The second most unlike (40.070). Italy – India. The less unlike (15.929) countries are U.S.A – India (Table 13).

Table 13 – Proximity Matrix

**Proximity Matrix**

| | Squared Euclidean Distance | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1: Brazil | 2: Canada | 3: Germany | 4: Spain | 5: U.K | 6: Hungary | 7: India | 8: Italy | 9: Mexico | 10: Portugal | 11: U.S.A |
| 1: Brazil | ,000 | 2,727 | 9,861 | 2,857 | 7,658 | 4,591 | 19,577 | 8,502 | 12,586 | 1,593 | 5,848 |
| 2: Canada | 2,727 | ,000 | 13,485 | 6,285 | 7,710 | 7,630 | 17,506 | 12,557 | 17,886 | 5,410 | 4,930 |
| 3: Germany | 9,861 | 13,485 | ,000 | 12,120 | 13,855 | 10,266 | 25,722 | 13,942 | 20,348 | 8,799 | 13,014 |
| 4: Spain | 2,857 | 6,285 | 12,120 | ,000 | 8,499 | 4,956 | 25,873 | 5,949 | 8,990 | 2,833 | 7,675 |
| 5: U.K | 7,658 | 7,710 | 13,855 | 8,499 | ,000 | 5,344 | 36,931 | 9,187 | 12,862 | 8,220 | 10,875 |
| 6: Hungary | 4,591 | 7,630 | 10,266 | 4,956 | 5,344 | ,000 | 32,495 | 6,586 | 8,614 | 4,403 | 12,823 |
| 7: India | 19,577 | 17,506 | 25,722 | 25,873 | 36,931 | 32,495 | ,000 | 40,070 | 40,549 | 23,052 | 15,929 |
| 8: Italy | 8,502 | 12,557 | 13,942 | 5,949 | 9,187 | 6,586 | 40,070 | ,000 | 11,619 | 8,612 | 14,605 |
| 9: Mexico | 12,586 | 17,886 | 20,348 | 8,990 | 12,862 | 8,614 | 40,549 | 11,619 | ,000 | 10,349 | 16,160 |
| 10: Portugal | 1,593 | 5,410 | 8,799 | 2,833 | 8,220 | 4,403 | 23,052 | 8,612 | 10,349 | ,000 | 5,712 |
| 11: U.S.A | 5,848 | 4,930 | 13,014 | 7,675 | 10,875 | 12,823 | 15,929 | 14,605 | 16,160 | 5,712 | ,000 |

This is a dissimilarity matrix

## 4.6 Affinity Diagram

Three open-ended questions encompassed the last part of the survey aiming at a deeper understanding of the respondents' perceptions. In this thesis, due to the time limitation, answers were selected from the countries considered in exploratory cluster analysis. Based on the carried-out literature review, affinity diagram was found to be the best tool to categorize open-ended questions (Holtzblatt & Beyer, 2017). The questions were;

I. What are your expectations concerning the Quality Professionals of the 21st Century based on their ability, knowledge and personal characteristic? (Please point out abilities that were not mentioned on the previous questions).
II. Do you think that the current quality tools are sufficient to deal with the new industry challenges? If your answer is no, could you please explain why?
III. Which quality tools may be combined in order to gain maximum resilience to face the new industry challenges?

Answers were analyzed, and brainstorming was carried out among QOE group members (Quality and Organizational Excellence). Then, each answer was ascribed to each of the emergent clusters. Each group encompasses answers which are similar to each other.
Regarding to first open-ended question (What are your expectations concerning the Quality Professionals of the 21st Century based on their ability, knowledge and personal characteristic?), answers were classified according to their similarity. See the figure below (Figure 24 – Figure 25 – Figure 26).

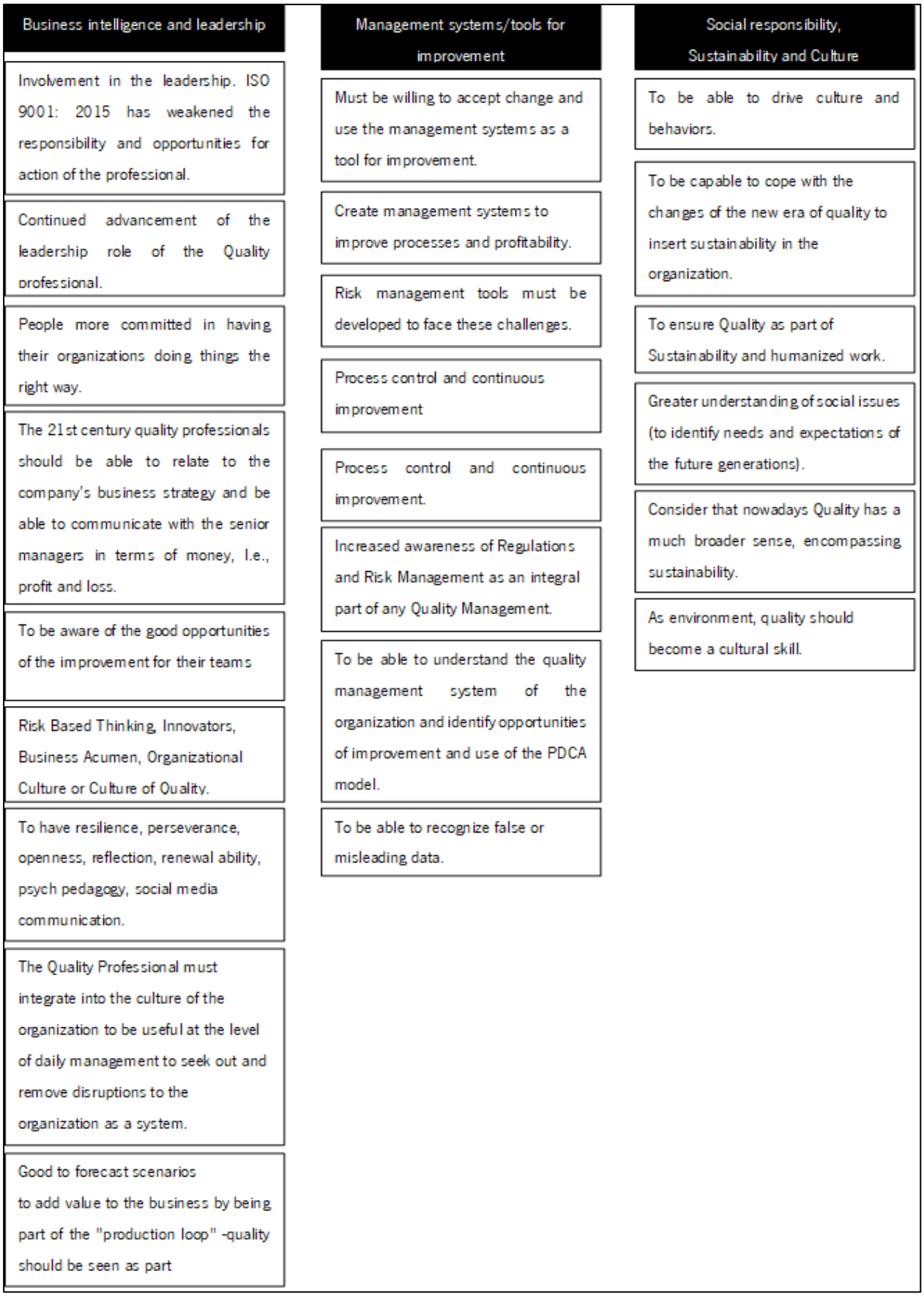



Figure 24 – Affinity Diagram of survey regarding to open-ended questions(I)

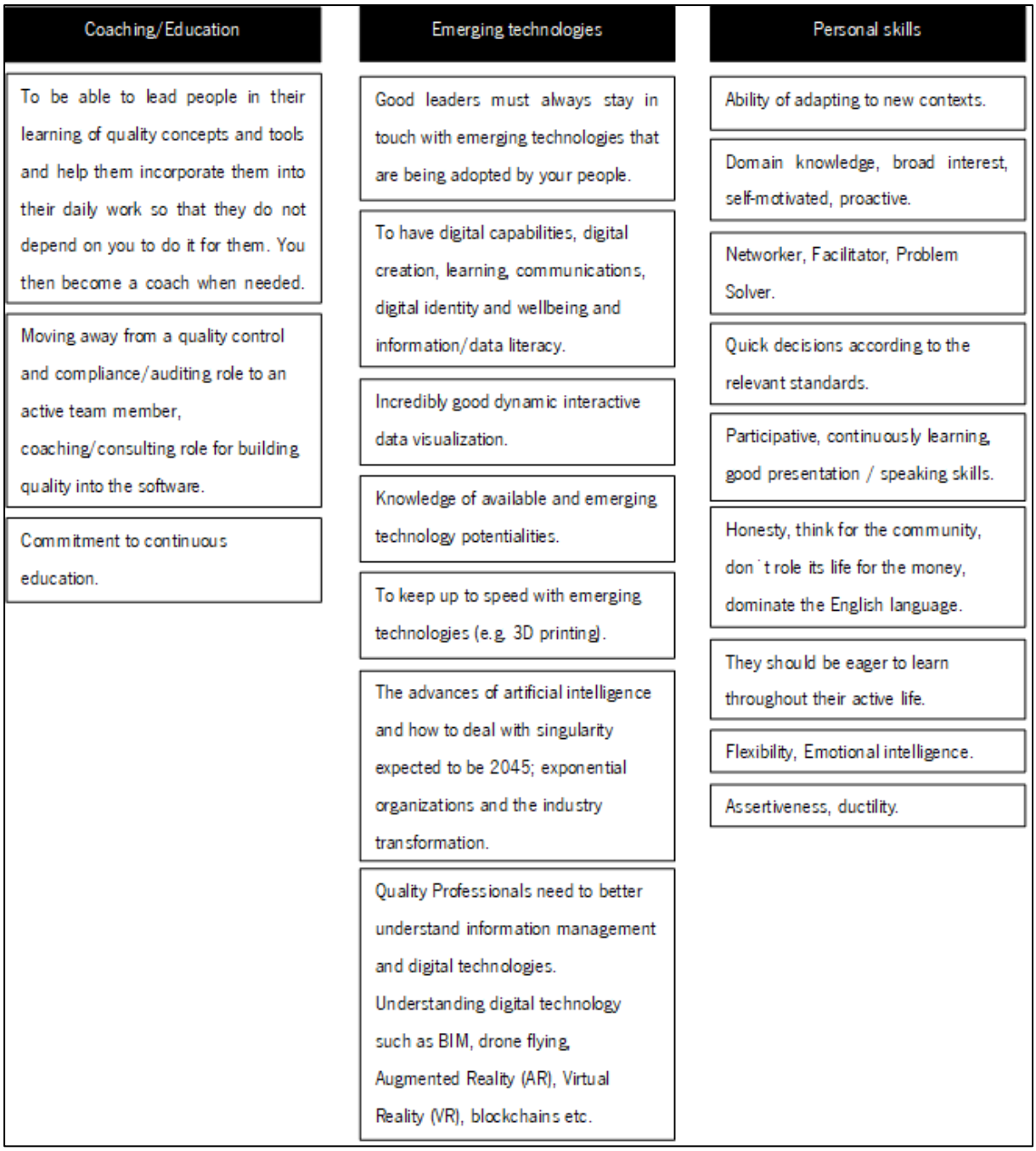



Figure 25 (Continuation) – Affinity Diagram of survey regarding to open-ended questions(I)

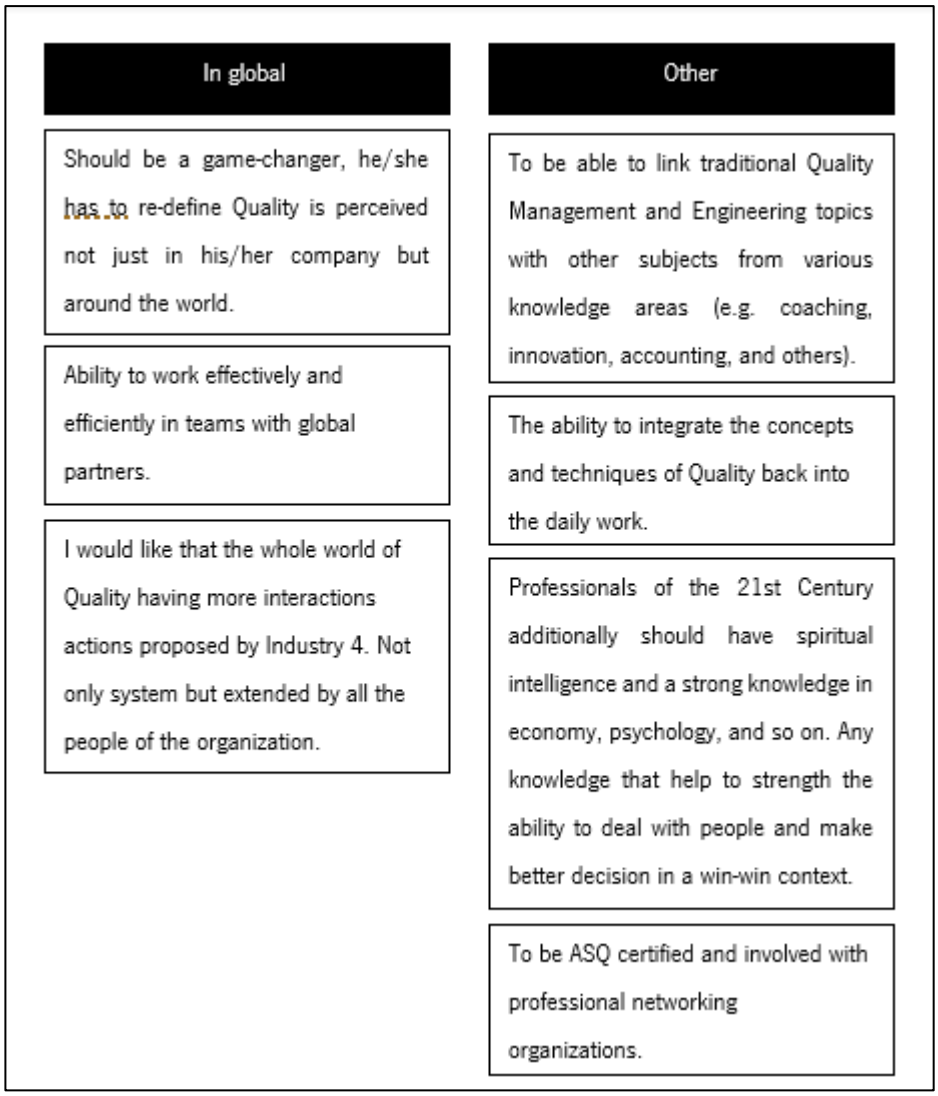



Figure 26 (Continuation) – Affinity Diagram of survey regarding to open-ended questions(I)

Regarding to the answers of the first open-ended questions, respondents stressed a great deal about being customer focus, even though it was mentioned in the survey (For this reason "being customer focus" title does not include in the affinity diagram figures). This subscribes and emphasizes respondents' opinion towards to being customer focus based on their expectations from Quality Professionals of the 21st Century. Other main titles were mentioned such as business intelligence and leadership, management systems/tools for improvement, social responsibility, sustainability and culture, coaching, education, emerging technologies, personal skills, in global and other. Some opinions from the respondents toward the changing of the roles. Regarding to "Coaching" title, quality professionals should lead people to learn quality concepts and they should move away from quality auditing role and become an active team member.

Regarding to second open-ended question (Do you think that the current quality tools are sufficient to deal with the new industry challenges? If your answer is no, could you please explain why?), respondents were asked a yes-no question, and if their answer is no, explanation of the reason was questioned. According to the results, 55% of the respondents answered “yes, current quality tools are sufficient to deal with the new industry challenges” and “No, current quality tools are not sufficient to deal with the new industry challenges” option was classified in the affinity diagram.
Answers were classified according to their similarity to each other. See the figure below (Figure 27 – Figure 28).

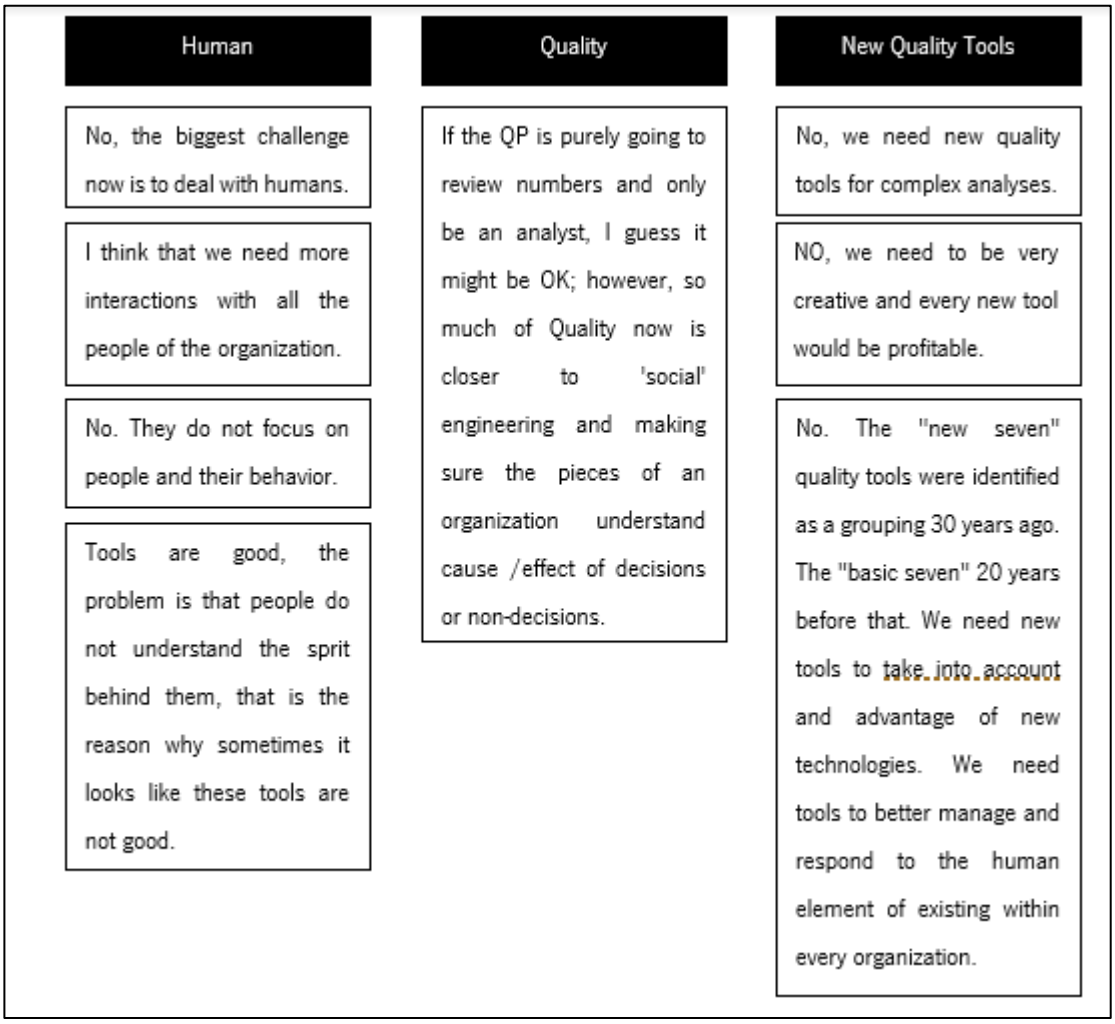



Figure 27 – Affinity Diagram of survey regarding to open-ended questions (II)

| Challenges, artificial intelligence | Integrate the tools | Market and technology | Other |
|---|---|---|---|
| No, the current tools do not address many of the current challenges in the industry. | I believe some tools should be integrated. | It has to be developed a lot, but a perfect adaptation to the market and the technologies is necessary. | No, there are fantastic tools on the market today, but I can see that some of them are still unanswered. |
| Quality tools are always improving, considering the challenges faced. No tool is "sufficient". | The current tool kits such as 8D, 5S, SPC, FMEA, PPAP etc. can be connected to live data sources and with smart algorithms be automated. | Quality tools and analytics are now part of IT application system. More knowledge of IT Systems/ Data helpful going forward. | Not designed for complex systems analysis. |
| We don't have quality tools for environments that are unique or constantly changing. | There needs to be more whole systems tools. | It will be needed to deep the knowledge around data science and IoT. | Not enough. More needs to be dealt with by developing cognitive abilities. |
| No, because the changing world always will require new tools according to the needs and challenges that would come. | | No, understanding big data. | |
| NO Because the world is more dynamic now with 4.0 era and artificial intelligence and people connected. | | No Innovative technologies & tools (like virtual reality, augmented reality etc.) to be adapted at full scale. | |
| No. The progress of artificial intelligence (including robotics, cyber decisions, etc.) will lead to the automatic field some tools used by humans. | | Quality professionals need to know about "big data" analytics that use a different set of techniques. | |
| No. Need to adapt to meet the challenges of information management. | | No. 4th industrial revolution requires new thinking and methods mastering big/smart data (analytics), supporting digitalization. | |
| Understand Artificial Intelligence and to control multiple variables on end to end processes. | | | |

Figure 28 (Continuation) – Affinity Diagram of survey regarding to open-ended questions (II)

With respect to Figure 27 – Figure 28, answers were classified in 7 clusters in the affinity diagram (human, quality, new quality tools, challenges - artificial intelligence, integrate the tools, market and technology and other). To sum up, a great deal of the answers stressed the "challenges - artificial intelligence" cluster. Other relevant cluster is "Market and Technology" encompassing big data, digitalization and information technology. Respondents feel that current quality tools should consider more information about big data, digitalization and information technology. Concerning the "Human Factor" cluster (according to the opinion of some of the respondents) "tools are good", but people do not understand the underlying spirit of those tools and therefore tools are becoming useless.
Regarding to third open-ended question (Which quality tools may be combined in order to gain maximum resilience to face the new industry challenges?), answers were classified according to their similarity to each other. See the figure below (Figure 29 – Figure 30).

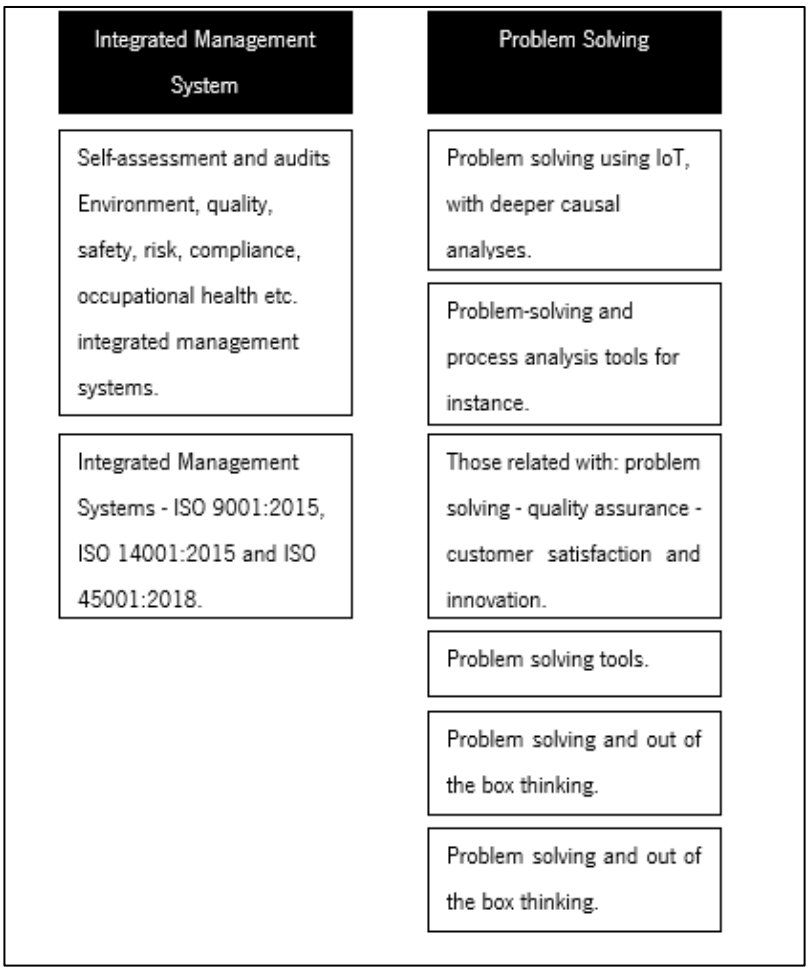



Figure 29 – Affinity Diagram of survey regarding to open-ended questions (III)

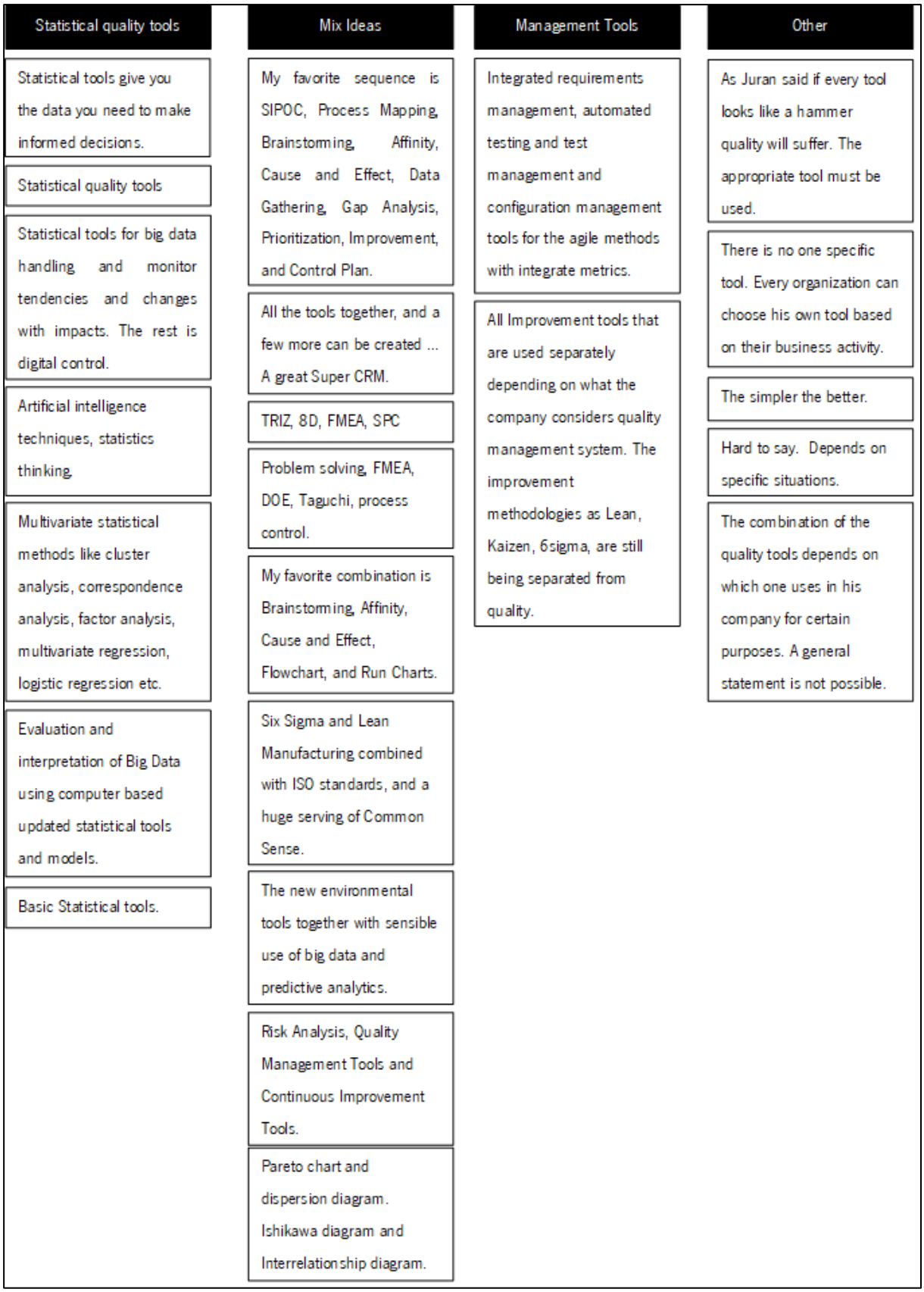



Figure 30 (Continuation) – Affinity Diagram of survey regarding to open-ended questions (III)

With respect to Figure 29 – Figure 30, answers were classified in 6 clusters in the affinity diagram (Integrated Management System (IMS), problem solving, statistical quality tools, mix ideas, management tools and other). Most of the answers were ascribed to the "Mix ideas" cluster. In addition, a great of respondents mentioned the statistical quality tools. They proposed to bring together statistical tools aiming at proactiveness in the 21st Century. Concerning the "Other" clusters, generally, respondents stressed that there is no need to collect different tools, to be simple is better and they mentioned that this situation is dependent on the organizations' needs.

## 5. CONCLUSIONS AND FURTHER RESEARCHES

In a globalized and developing world facing properly the new emergent challenges is extremely important. Today customer expectations are increasing, and new concepts are emerging such as Smart Factories, Industry 4.0, Quality 4.0 and social responsibility. In such a world, being solely Quality Professional is not enough and this profile should be updated with skills and competences. Quality Professionals with skills and competences will face with challenges of the 21st Century successfully. This study started with a comprehensive literature review by using keywords such as "Quality Professionals", "21st Century Challenges", "Quality 4.0", "Skill and competence". Several relevant results were found, and some research gaps were identified.

To figure out whether current Quality Professionals are ready or not to face challenges of the 21st Century, an online survey was carried out all around the world. This research aimed at bringing light to some questions, such as; What are the crucial skills & competencies for the Quality Professionals of the 21st Century?, What are the general expectations from Quality Professionals of the 21st Century? Are current quality tools sufficient to deal with the new industry challenges?

The online survey encompassed three parts. First part addressed individual and organization-based questions. In this part, respondents' organizational roles, age ranges, countries, sectors and experience years were identified. Also, the number of employees of the organizations, the annual turnover and the percentage of organizations' activity in the international market were evaluated. The second part encompassed 5 Point Likert importance scale including 27 expressions aiming at rating the skills. The 5 Point Likert scale ranged from "1- Unimportant" to "5- Extremely Important". The last part included three open-ended questions.

Results suggest that the most important skill dimension is Management Skills. In addition, the most important individual item seems to be "Being customer focused". According to Kruskal-Wallis-H test, results suggest that assessment of the variables differ according to some grouping variables (macro region, organizational roles etc.). This means that respondents from different macro region/organizational role assessed variables differently from other respondents from another macro region/organizational role. This part is important for further research suggestions, because in this research the reason of this divergence could not explain and for this reason, to figure out the reason of this divergence can be another hot topic for further researches. Concerning the results collected from the exploratory cluster analysis, Portugal and Brazil have the strongest relationship in terms of the similarity. According to the answers of open-ended questions the respondents' expectations regarding Quality Professionals of the 21st Century rely a great deal on "being customer focused". In addition to this,

- To have business intelligence and leadership,
- To be able to use management systems/ tools for improvement,
- To be able to drive culture and behaviors, shortly social responsibility, sustainability and culture, coaching,
- To be able to lead people, moving away from a quality control and compliance role and to be an active team member,
- Always getting stay in touch with new technologies,
- Developing personal skills,
- Effective work in global.

At the same time, this research can bring light into educational environment in terms of teaching of the most necessary skills and competences, thus more knowledgeable quality professionals can be raised.

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# ATTACHMENT I



## The Profile of the Quality Professional of the 21st Century

Universidade do Minho
Escola de Engenharia

My name is Ilknur Uzdurum. I am a student of the Quality Engineering and Management Master Program at the University of Minho, Portugal. I am working on my graduation dissertation under the supervision of Professor Paulo Sampaio. This survey assumes a core role in my dissertation project. For this reason I would like to thank you in advance for being a part of this work.
The purpose of this research is to define the profile of the Quality Professional of the 21st Century, based on the new challenges that the organizations are currently dealing with.
The data collected are anonymous, confidential and no identification of the respondent is required. The collected data will only be used for research purposes.

Welcome to the survey!
The questions and items that you are going to answer and assess in the following two pages aim to clarify the required skills and competences for Quality Professionals Profile of the 21st Century. The estimated time to complete the survey is approximately 8 minutes.

**Organization and respondents' characterization**
This section includes individual and company based questions.

***1.1* Gender**

○ Female ○ Male ◉ No answer

* ***1.2* Age**

*Only numbers may be entered in this field*

* ***1.3* Country**
**Choose one of the following answers**

Please choose...

* ***1.4* Please indicate your current activity sector.**
**Choose one of the following answers**

○ Education

- Healthcare
- Industry
- Service
- Social
- Other:

* ***1.5*** **Please indicate your active role in your organization.**
**Choose one of the following answers**

- CEO (Chief Executive Officer)
- Quality Manager
- Quality Engineer
- Quality Assurance and Certification Supervisior
- Quality Control and Planning Supervisior
- Quality Management System Supervisior
- Quality Technician
- Quality Specialist
- Professor
- Other:

* ***1.6*** **For how many years do you play an active role in the quality field?**
**Choose one of the following answers**

- Less than 2
- Between 2 and 5
- Between 6 and 15
- More than 15

* ***1.7*** **Please indicate the number of employees in your organization.**
**Choose one of the following answers**

- Less than 10
- Between 11 and 50
- Between 51 and 250
- Between 251 and 500
- More than 501

* ***1.8*** **Please indicate the percentage of your organization activity in the international market.**
**Choose one of the following answers**

- Less than 2%
- Between 2% and 8%
- Between 9% and 15%
- Between 16% and 25%
- More than 25%

* ***1.9*** **What is the annual turnover (in US$) of your organization?**
**Choose one of the following answers**

- Less than 0.5M
- 0.51 - 5M
- 5.1 - 10M
- 10.1 - 50M
- More than 50.1M

* ***1.10*** **What is the number of sites of your organization?**
**Choose one of the following answers**

- 1
- 2
- 3-5
- 6-10
- 11-50
- More than 50

* ***1.11*** **Is your organization certified according to the ISO 9001 standard?**

- Yes
- No

**The most relevant competencies for the Quality Professionals**

This section includes 5 Points Likert Scale questions and Open-Ended ones.
Concerning the 5 Point Likert Scale questions, the items to be assessed encompass several dimensions, namely: Technical Skills; Soft Skills; Leadership Skills; Management Skills and Analytical Skills. Concerning the Open-Ended Questions there are 3 short questions that ask your opinion regarding specific topics.

* **2.1 Please rate the importance of the following technical skills according to the Likert Scale.**

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To have skills on abstract thought. (Ex: To visualize data from productive processes and to make decisions based on it in order to optimize the overall system) | ○ | ○ | ○ | ○ | ○ |
| To be an expert in the underlying issues revolving around Industry 4.0 (Smart systems, technological devices), Quality 4.0 and Big Data. | ○ | ○ | ○ | ○ | ○ |
| To be an expert in Quality Control Tools, Quality Management Tools and to properly use the Continuous Improvement Tools. | ○ | ○ | ○ | ○ | ○ |
| To be an expert in troubleshooting techniques. (Ex: maintenance, repair, operation & control) | ○ | ○ | ○ | ○ | ○ |
| To be able to work with Information Technology (IT) tools. (Ex: Visual Programming, interaction with digital interfaces, etc) | ○ | ○ | ○ | ○ | ○ |

* **2.2 Please rate the importance of the following soft skills according to the Likert Scale.**

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To have emotional intelligence. | ○ | ○ | ○ | ○ | ○ |
| To be persuasive. | ○ | ○ | ○ | ○ | ○ |
| To be a creative and an innovative person. | ○ | ○ | ○ | ○ | ○ |
| To be altruistic. (Social and Environmental awareness, Volunteer work) | ○ | ○ | ○ | ○ | ○ |

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To be able of working in a team. | | | | | |
| To be ambitious, open minded, active and a continuous learner for every new idea emerged. | | | | | |
| To be able to create a wide social network. | | | | | |
| To be an expert in complex problem solving. | | | | | |
| To be able to adapt into changing roles. | | | | | |
| To have cognitive flexibility and to be able to logical and critical reasoning. | | | | | |
| To be a good communicator. (Good listener and writer adopting the proper language) | | | | | |

* **2.3 Please rate the importance of the following leadership skills according to the Likert Scale.**

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To be instructive, assistant and able to point out alternatives and new paths supported on leaders' own knowledge and experience. | | | | | |
| To encourage and motivate employees towards the improvement of their less developed skills. | | | | | |
| To be in touch and coordinative with all departments. | | | | | |
| To be able to delegate. | | | | | |
| To be fair and objective when making decisions. | | | | | |
| To be capable to moderate difficulties in case of negative situation. | | | | | |

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To be able to congratulate, to punish and to reward employees at the proper occasion. | ○ | ○ | ○ | ○ | ○ |

* **2.4 Please rate the importance of the following management skills according to the Likert Scale.**

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To be aware and attentive towards the needs and expectations of the customer. | ○ | ○ | ○ | ○ | ○ |
| To have good management skills. (Human resources, financial resources, material resources, risk, time and conflict management) | ○ | ○ | ○ | ○ | ○ |

* **2.5 Please rate the importance of the following analytical skills according to the Likert Scale.**

| | Unimportant | Somewhat Important | Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| To be good at analytical and mathematical reasoning, data mining and text analytics. | ○ | ○ | ○ | ○ | ○ |
| To be capable of properly adopt the suitable statistical tools and methodologies. | ○ | ○ | ○ | ○ | ○ |

**2.6 What are your expectations concerning the Quality Professionals of the 21st Century based on their ability, knowledge and personal characteristic? (Please point out abilities that were not mentioned on the previous questions).**

**2.7 Do you think that the current quality tools are sufficient to deal with the new industry challenges? If your answer is no, could you please explain why?**

**2.8 Which quality tools may be combined in order to gain maximum resilience to face the new industry challenges ?**

Load unfinished survey | Resume later | Submit | Exit and clear survey

# ATTACHMENT II

| Question Number | Expression | Scale | Numerical Transformation |
|---|---|---|---|
| **1.1** | Gender | Female | 1 |
| | | Male | 2 |
| | | No Answer | 3 |
| **1.2** | Age | 23-29 | 1 |
| | | 29-35 | 2 |
| | | 35-41 | 3 |
| | | 41-47 | 4 |
| | | 47-53 | 5 |
| | | 53-59 | 6 |
| | | 59-65 | 7 |
| | | 65-71 | 8 |
| | | 71-77 | 9 |
| | | 77-83 | 10 |
| | | 83-89 | 11 |
| **1.3** | Country | Australia.... Vietnam | 1...61 |
| **1.4** | Please indicate your current activity sector. | Education | 1 |
| | | Healthcare | 2 |
| | | Industry | 3 |
| | | Service | 4 |
| | | Social | 5 |
| | | Other | 6 |
| **1.5** | Please indicate your active role in your organization. | CEO (Chief Executive Officer) | 1 |
| | | Quality Manager | 2 |
| | | Quality Engineer | 3 |
| | | Quality Assurance and Certification Supervisior | 4 |

| | | | |
|---|---|---|---|
| | | Quality Control and Planning Supervisior | 5 |
| | | Quality Management System Supervisior | 6 |
| | | Quality Technician | 7 |
| | | Quality Specialist | 8 |
| | | Professor | 9 |
| | | Other | 10 |
| | | | 11 |
| **1.6** | For how many years do you play an active role in the quality field? | Less than 2 | 1 |
| | | Between 2 and 5 | 2 |
| | | Between 6 and 15 | 3 |
| | | More than 15 | 4 |
| **1.7** | Please indicate the number of employees in your organization. | Less than 10 | 1 |
| | | Between 11 and 50 | 2 |
| | | Between 51 and 250 | 3 |
| | | Between 251 and 500 | 4 |
| | | More than 501 | 5 |
| **1.8** | Please indicate the percentage of your organization activity in the international market. | Less than 2% | 1 |
| | | Between 2% and 8% | 2 |
| | | Between 9% and 15% | 3 |
| | | Between 16% and 25% | 4 |
| | | More than 25% | 5 |
| **1.9** | What is the annual turnover (in US$) of your organization? | Less than 0.5M | 1 |
| | | 0.51 - 5M | 2 |
| | | 5.1 - 10M | 3 |
| | | 10.1 - 50M | 4 |
| | | More than 50.1M | 5 |
| **1.10** | What is the number of sites of your organization? | 1 | 1 |
| | | 2 | 2 |
| | | 3-5 | 3 |
| | | 6-10 | 4 |
| | | 11-50 | 5 |

| | | | |
|---|---|---|---|
| | | More than 50 | 6 |
| **1.11** | Is your organization certified according to the ISO 9001 standard? | Yes | 1 |
| | | No | 2 |
| **2** | Please rate the importance of the following technical skills according to the Likert Scale. | Unimportant | 1 |
| | | Somewhat Important | 2 |
| | | Important | 3 |
| | | Very Important | 4 |
| | | Extremely Important | 5 |